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Technology Department

ON THE COVER

ALTHOUGH the first "cat" cracker was put in service only six years ago, these units are now found in almost every large American petroleum refinery. Winston Churchill mentioned them as one of the chief aids to the Allies in winning "the battle of octanes." Of a height that dominates the refinery skyline (note boxcars in front) they cost $5,000,000 and more each. The powdered catalyst, that assists but does not enter into the process of cracking the crude-oil molecules, is transported in a steam of compressed air during a phase of the cycle. The three units pictured on our cover are in a Gulf Coast refinery of Cities Service Company. The photograph was taken by Robert Yarnall Richie for the M. W. Kellogg Company, which designed and erected the units.

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IN THIS ISSUE

WHEN you turn on a water faucet you can see the fluid running, but you have no way of knowing whether your neighbor also has his tap open. You would have to go there to find out. If a large oil refinery had to have men stationed at all operating points to turn on valves and note whether all the apparatus were functioning at the prescribed pressures, temperatures, and rates of flow, a veritable army would be required and we should probably pay more than we do now for the hundreds of useful products that have their origin in petroleum. Fortunately, there are inanimate operators to perform most of these tasks. These tireless robots not only do their countless jobs without fail but also send back continuous reports to a centrally located control room where the story of what is going on is presented in graphic form. As told in our leading article, air-operated instruments play an important part in this fascinating procedure.

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TUNNELING of the English Channel, talked about for two centuries and actually started 70-odd years ago, is once again being seriously studied. The history of this intriguing engineering project and an appraisal of the benefits it would offer if carried out are presented in the article starting on Page 161.

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A GLIMPSE of the research facilities General Aniline & Film Corporation maintains to keep its products abreast of the times is given in the article beginning on Page 167.

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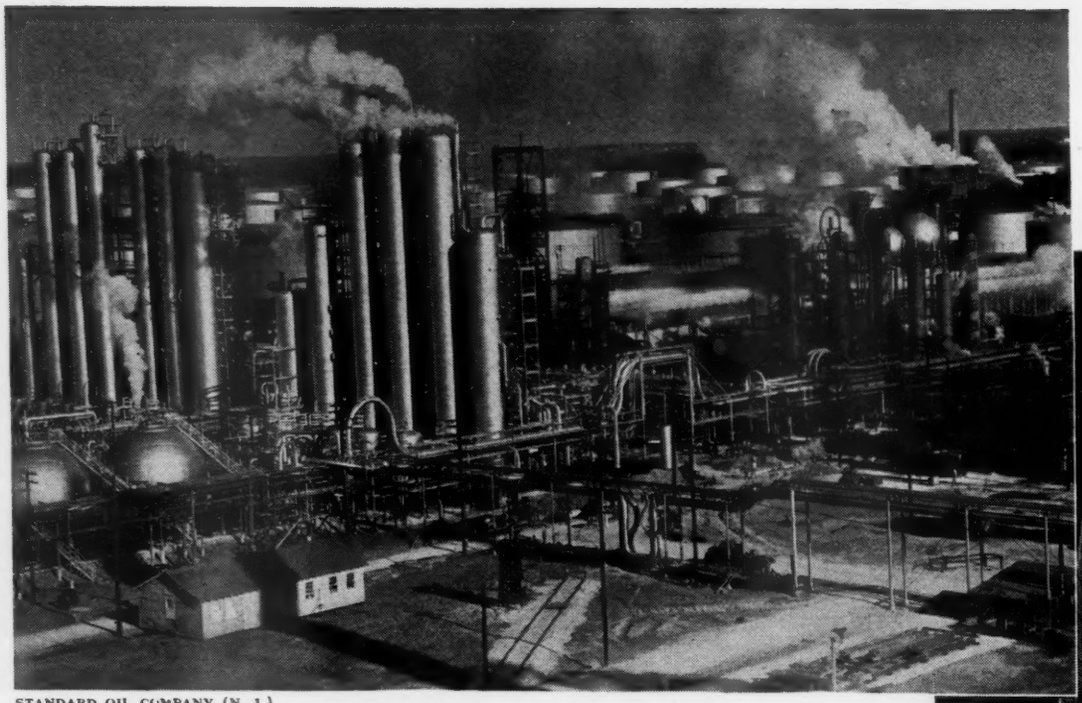
Controllin

an Refin

W. P. Gillingh



STANDARD OIL COMPANY (N. J.)

MODERN REFINERY

Part of the Baytown, Tex., refinery of Humble Oil & Refining Company, one of the world's largest oil-processing plants. A light-ends fractionating unit is seen in the left foreground.

M. W. KELLOGG COMPANY

THOSE who are fortunate enough to visit a modern oil refinery are often amazed at the magnitude of the operations. Huge fractionating towers, tanks, agitators, condensers, evaporators, chillers, and other equipment supply extremes in pressure, heat, and cold needed to convert crude oil into diverse products. Miles of piping connect the different processing units, some of which rise more than 100 feet into the air. Yet visitors are often less impressed by their size than by the ease with which they are controlled.

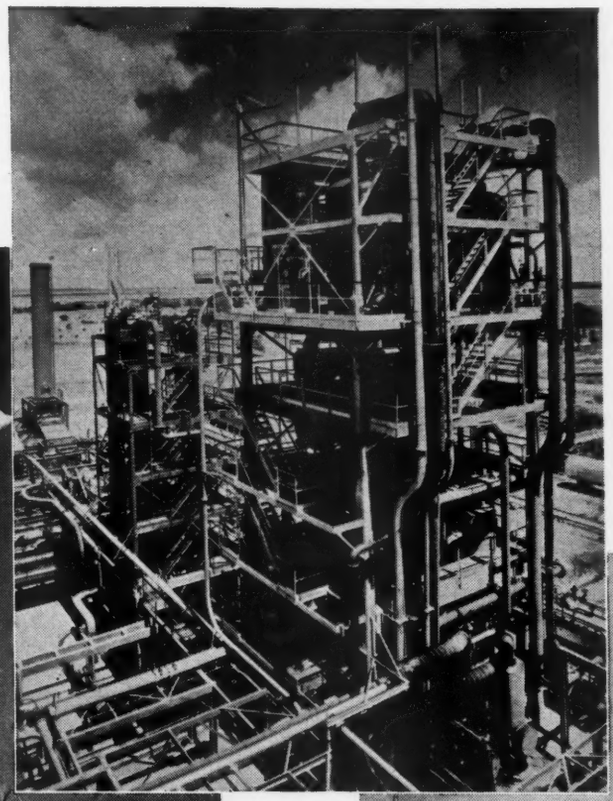
Compared to the average manufacturing plant of equal size, the refinery employs relatively few workmen, and they seem more concerned about keeping it clean than about the operation of the equipment. There is no shouting, no rushing around—only the strange sound of the hot gases rushing through the pipes. In the central control room, lined with banks of instrument panels, the attendant will occasionally adjust a dial, but otherwise the place appears to run itself. This seeming lack of supervision is misleading, however, for each step in the process of petroleum refining is constantly and carefully controlled—not by men, but by automatic instruments which never relax their vigilance. A great many of these instruments are air operated, and the history of their development is closely allied with the growth of the petroleum-refining industry.

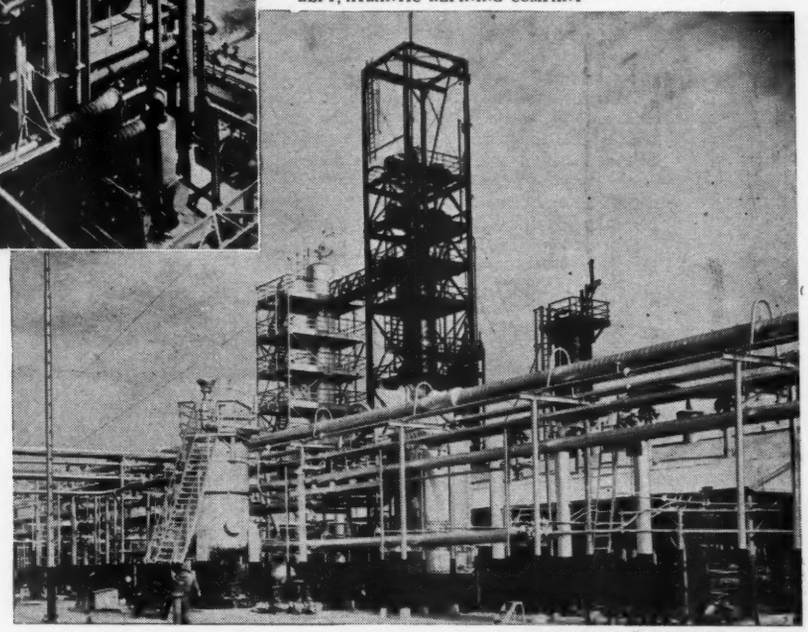
Petroleum refining has come a long way since the days, scarcely a hundred years ago, when crude oil seeping from the ground was gathered and sold for its supposed medicinal value. Refining was resorted to when it was found that treated crude could be used as an illuminant. Kerosene lamps were the result. Later it was discovered that petroleum products made excellent lubricants for machinery. This firmly established the industry, which received further impetus upon the advent of the internal-combustion engine. Today, petroleum refining the world over is developing so rapidly that newly invented processes sometimes are outdated even before they can be applied. A modern refinery costs millions of dollars, turns out thousands of gallons of products daily, and may become obsolete within a comparatively short period. There are more than 500 such plants operating in the United States, and their total refining capacity exceeds 4,500,000 barrels of crude oil daily.

Petroleum as it comes from the earth is practically useless. It is only when refining has transformed it into hundreds of products that its real worth is realized. Crude oil is composed mainly of carbon and hydrogen combined into a countless variety of hydrocarbons, each group or fraction of which will boil within a definite temperature range. When heat is applied to petroleum, the hydrocarbons boil off as vapors, which differ in composition from the parent liquid. When they are condensed and that liquid is heated, the resultant vapors again differ in composition from the condensate. It is this property of crude oil that enables the refiner to separate it into various fractions which can be further processed.

This method of separation is known as fractional distillation and was formerly a "batch" process in that only a certain amount of petroleum was treated at a time. When a batch had been separated into the desired number of fractions, the equipment was cleaned and a fresh one was introduced. The work of boiling the liquids and condensing the vapors was done in separate stages, a procedure that was known as "rerunning."

Modern fractional distillation is a continuous process by which six or more fractions are obtained simultaneously in a fractionating column, a tall cylindrical tower often more than 100 feet high. Shallow steel trays or plates spaced at intervals of about 2 feet divide the structure into sections. Each tray has



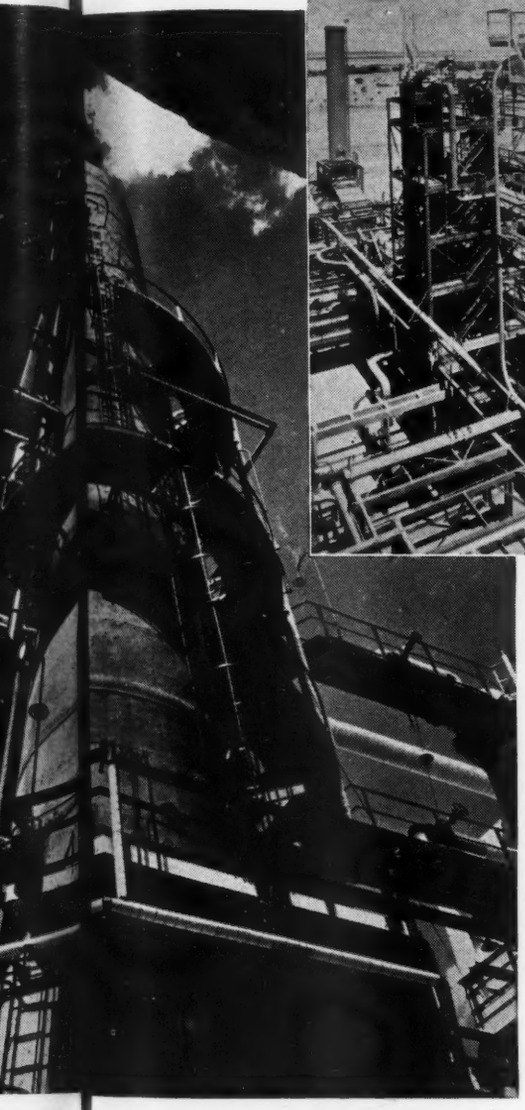


MILES OF PIPES

Each of the many individual processing units of a large refinery appears as a network of pipes and structural steel that partially hides the apparatus where hydrocarbons are juggled well-nigh at will. One of the units shown (left) is a polymerizer in which the unstable molecules of the light, highly volatile gases released by the cracking of crude oil are rearranged into heavier, more cohesive ones suitable for use as fuel in modern high-compression combustion engines. Below is an isomerization unit which converts butane into isobutane, a vital ingredient of an alkylate blending agent used in making 100-octane aviation gasoline. In the case of every process, oil, gases, compressed air, and steam travel through a veritable maze of piping that connects the different units. The speed of flow, the temperature, and the pressure must be carefully controlled in each pipe.

LEFT, ATLANTIC REFINING COMPANY

HUMBLE OIL & REFINING COMPANY



FRACTIONATING TOWER

In this huge apparatus crude oil is separated into "cuts" or fractions, each of which forms the base stock for the manufacture of a specific class of products. Such a tower often yields more than 500 gallons of liquid fractions in the course of a minute.

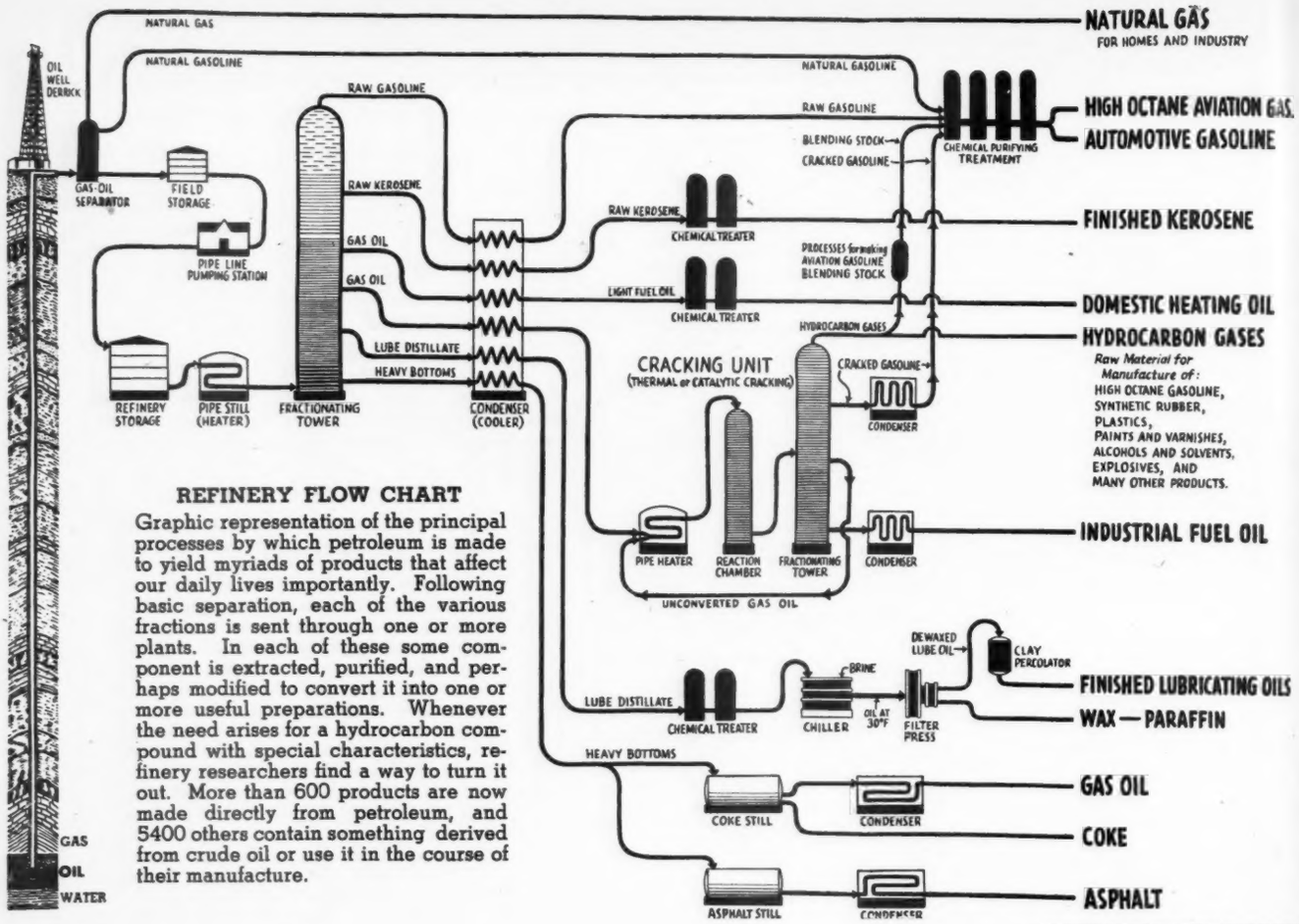
hundreds of perforations, and from each hole rises a short length of pipe surmounted by a cap designed so as to cause rising vapors to bubble through the condensate in the tray.

Crude oil is first put through a pipe heater which raises its temperature to between 650-750°F., depending upon the type. This is well above the boiling points of more than half of its hydrocarbons, but as the oil is confined within the pipe and under high pressure it cannot boil. It is only when the heated oil is discharged into the vaporizing section of the tower that it can expand and flash into vapor. As the ascending vapors bubble through the liquid in the trays, the hydrocarbons are progressively separated, those possessing the higher boiling points being condensed in the lower trays and those having the lower boiling points in the upper trays, the temperature within the tower decreasing gradually from bottom to top. When a tray overflows to the next below it, some of the liquid is again vaporized. As a result, many boilings and condensations take place simultaneously on the plates in the fractionating column.

At particular points in the tower the trays are tapped and their fractions pass to individual small columns where rising steam "strips" them of impurities and where further fractional distillation removes others. The gasoline vapors, being the least condensible of the lot, are drawn off at the top of the tower and liquefied in an external cooler. All the fractions are still further purified by washing in water, lye, or sulphuric acid; by filtration through clay or Fuller's earth; by solvent extraction and dewaxing processes; or by heating, sweating, or refrigeration.

It is the fractions separated from the crude oil which the refiner converts by numerous complicated processes into the more than 600 products that find their way into our homes, factories, farms, and transportation systems. There are separate plants for the blending of lubricants, the compounding of greases, the preparation of asphalts, and the segregation of the elusive petroleum gases required in the making of synthetics. The proverbial packer who utilizes every bit of the pig except its squeal has nothing on the refinery man, for the latter uses even the evil-smelling odors in gasoline. These, in the form of mercaptans, are combined with natural gas so that householders can easily detect leaks in gas lines.

At well-nigh every stage in the opera-



REFINERY FLOW CHART

Graphic representation of the principal processes by which petroleum is made to yield myriads of products that affect our daily lives importantly. Following basic separation, each of the various fractions is sent through one or more plants. In each of these some component is extracted, purified, and perhaps modified to convert it into one or more useful preparations. Whenever the need arises for a hydrocarbon compound with special characteristics, refinery researchers find a way to turn it out. More than 600 products are now made directly from petroleum, and 5400 others contain something derived from crude oil or use it in the course of their manufacture.

AMERICAN PETROLEUM INSTITUTE

tions, a percentage of the several distillates recovered is retained as stock for the manufacture of gasoline by cracking. The tremendous growth of the automotive and aviation industries has made gasoline the keystone of the petroleum industry, and research chemists have racked their brains to discover ways and means of getting more and better gasoline from each barrel of crude. The answer has been found in cracking, and this process has been the salvation of the industry. It was discovered in 1861 through the carelessness of a still operator who, enticed by a nearby saloon, left his 16-barrel, wrought-iron still unattended until it overheated. The work is now carried out in mammoth plants costing millions of dollars. The secret of its success lies in the fact that high temperatures cause heavy oils to break down or "crack" into lighter oils, which can then be separated by distillation into gasoline and other fractions.

When first developed, cracking was done in a heavy, cylindrical steel tank containing a batch of crude which was heated for 24 hours under a pressure of approximately 75 psi., the lighter oils being removed by ordinary distillation. This proved too slow, however, so by 1923 a continuous process, known as the tube-and-tank method, was put in operation. By it the oil was heated to 900°F. and then forced under high pressure into a large steel chamber where the oil cracked. Even this procedure was not without its faults, for the excessively high temperatures involved converted some components of the crude oil into coke and gas rather than into gasoline, so the refiner again retired into his research laboratory and presently emerged with catalytic cracking.

This particular brand of refinery magic introduces into the oil a foreign substance called a catalyst which does not enter into reaction with the oil but has a remarkable effect on the product—the result being a higher yield of better-grade gasoline. There are several processes of this kind in use today, and one of the most interesting of these is fluid catalytic cracking. The catalyst in this case is a finely ground silica-alumina compound that is fluffed up with gas or compressed air so that it flows and can be mixed with the oil on its way to the reaction chamber. These cracking processes result in the recovery of from 40 to 50 percent of 80-octane gasoline which, through redistillation and the addition of tetraethyl lead, provides a large percentage of the 100-octane fuel required by the aviation industry.

Because of the ever-increasing demands for new and better petroleum products, the refiner is ceaselessly juggling the atoms of the hydrocarbon molecules—tearing them apart and rearranging them into new and different forms, using heat and pressure. When it is realized that literally thousands of hydrocarbons exist within a temperature range of a few hundred degrees, it can be seen that precise control is necessary if the desired results are to be obtained. A slight change in temperature, in pressure, or in the amount of liquid flowing at a certain stage may affect a product to such an extent as to make it unsuitable for its intended purpose. Automatic control is therefore essential, for most processes have grown so complicated and are conducted on such a large scale that manual control would be an impossibility.

There are several reasons why pneumatic instruments are preferred over electric systems for the control of a great many refinery operations. They are of comparatively simple construction, extremely flexible, and any good mechanic can quickly learn to install and service them. Because there is no risk of shock, they can be handled with safety. Natural gas from well or pipeline may serve as the operating medium if compressed air is not available. Another factor vital to the refinery man is that air-operated apparatus can be used without risk in hazardous atmospheres where a spark from electric equipment might cause an explosion. In addition, a pneumatic system affords better protection against

loss of control through power failure because there is usually a sufficient reserve of compressed air on hand to last until manual control can take over. Furthermore, a small leak in the supply line merely results in an increase in air consumption, not in the complete loss of control that would follow a short circuit in an electric instrument.

The most important function of pneumatic instruments in petroleum refining is the control of such variables as pressure, temperature, rate and volume of flow, and liquid level. Certain of them indicate the condition of the variable on a dial, while others record it continuously on a chart with a pen or marker. Still others are equipped with apparatus that enable them to control the variable. Furthermore, all may perform their respective services mounted in a case on the side of a refinery unit, or they may transmit messages to a central control room and receive orders from the operator in charge there.

No matter what the function, pneumatic instruments have certain basic principles in common. They must first measure the condition of a medium before they can control or change that condition. Further, the measuring device must be provided with a control valve positioned by a spring-loaded diaphragm. Finally, all air-operated instruments are based on the "restriction" principle; that is, the ratio of supply-air pressure to valve-operating pressure depends upon the dynamic balance between the air entering the system and that bleeding from the system. The air supply is kept constant, but the amount escaping is varied by opening or covering the discharge nozzle or orifice with a metal flapper. The resultant changes in air pressure between the orifice and the point of supply cause the control valve to function.

The first pneumatically operated controllers developed for the oil industry were of a simple bimetallic type fitted with a ball-valve relay. Their "throttling" action was none too satisfactory, however, and they were soon superseded by the 2-position or "on-off" type, an example of which is shown in Figure 1. It operates in the same manner in which the ordinary household thermostat regulates the home heating plant. One of its typical refinery applications is that of controlling the temperature of crude oil being heated in preparation for processing.

As has previously been stated, the first duty of the instrument is to measure the variable it is to control. This is usually accomplished by inserting at some point in the system a bulb or other small container connected by capillary tubing to a hollow, coiled tube—commonly called a Bourdon tube—within the instrument. Its free end is sealed off, and the entire assembly of bulb, capillary, and Bourdon tube is filled with a highly expansible gas. Next, the instrument is connected by small-diameter copper tubing to a valve that regulates the heat to which the crude oil is subjected and, finally, to a source of constant-pressure air.

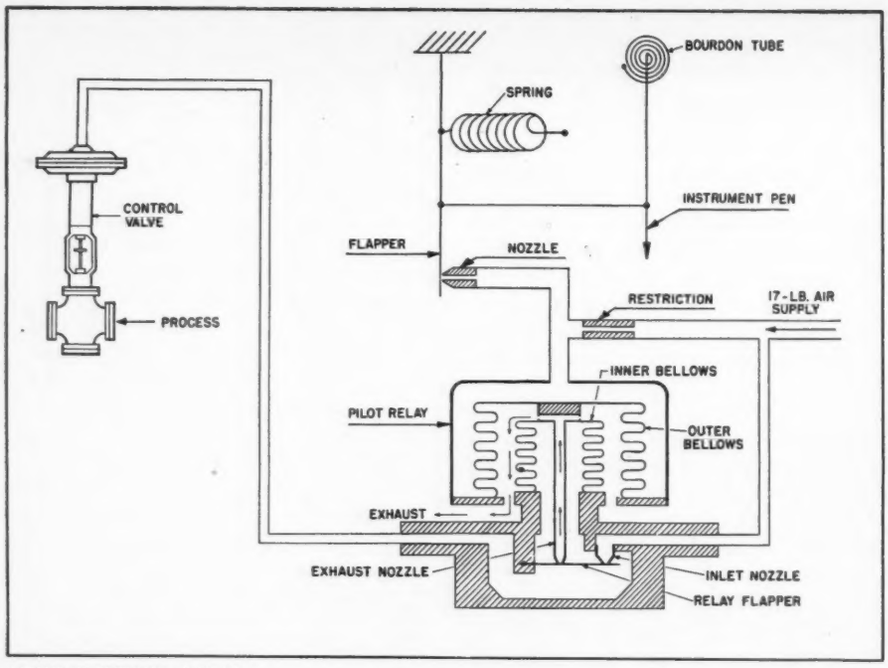
An important component of any pneumatic control is the pilot relay, which varies greatly in design. The type shown in Figure 1 consists of two bellows one inside the other. They are fastened together rigidly, and the area of the outer one is three times that of the inner. It also has a metal flapper which covers two nozzles, one an inlet connected to the air-supply line and the other an exhaust nozzle. Although the instrument could function without the pilot relay, all the air required to operate the control valve would have to pass through the restriction, causing an appreciable time lag. The use of the pilot relay, which has a capacity 30 times that of the restriction with its nozzle arrangement, permits rapid filling and exhausting of the air line to actuate the control valve.

When the temperature of the medium being processed is anywhere between the upper and lower limits for which the instrument has been set, the controller is in a state of dynamic balance, with opposing forces equalized. Under those conditions, the position of the main-instrument flapper in front of the nozzle is such that the volume of air escaping is equal to that flowing through the restriction. The flapper of the pilot relay then covers both the inlet and the exhaust nozzles, as shown in the drawing. Now, if the temperature drops below the lower limit, the gas pressure in the measuring device will fall and allow the Bourdon tube to coil itself more tightly, thereby moving the main-instrument flapper closer to the

HUMBLE OIL & REFINING COMPANY

MEANS OF CONTROL

Slender lines of compressed air encased in tubing are the reins that control the operations of many refining processes. More than a hundred of them are seen at the left on the roof of the control house of a butyl plant. The control room is the nerve center with its precise instruments that send out pneumatic impulses to regulate heat, pressure, rate of flow, etc. For the most part they are automatic, and only an occasional adjustment of the knobs on the panel board suffices to keep the various units working smoothly and in unison. Above is shown an operator checking the record of a particular process.



BROWN INSTRUMENT COMPANY

BASIC PNEUMATIC CONTROLLER (FIGURE 1)

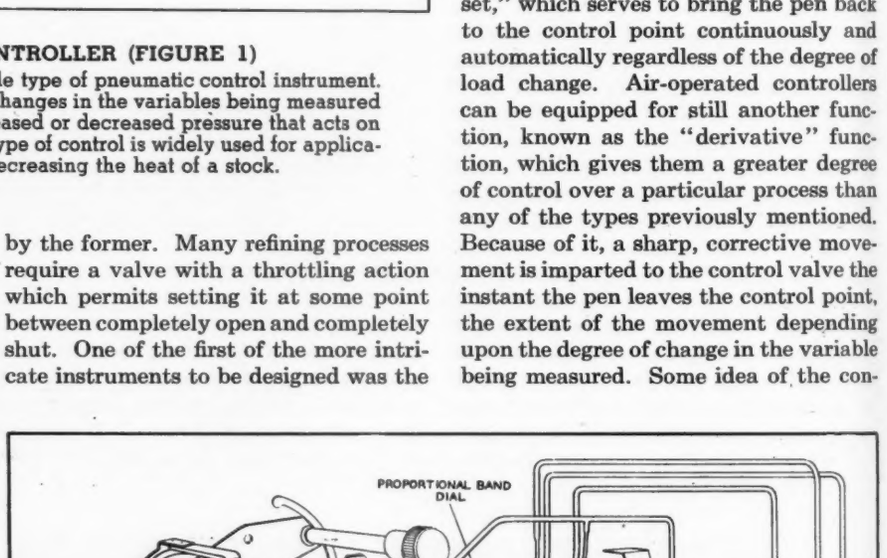
Diagram shows the construction of a simple type of pneumatic control instrument. Its operation is explained in the article. Changes in the variables being measured are translated by the instrument into increased or decreased pressure that acts on the diaphragm of the control valve. This type of control is widely used for applications such as periodically increasing or decreasing the heat of a stock.

nozzle. This action increases the pressure between the nozzle and the restriction, thus forcing the exhaust nozzle of the pilot relay against its flapper and uncovering the inlet nozzle. Air from the supply line then enters and operates the diaphragm of the control valve, causing the latter to open and to permit more heat to reach the crude oil. At the same time, pressure builds up inside the smaller of the two bellows until the opposing forces are balanced and the relay flapper again closes the inlet nozzle.

Conversely, with a rise in temperature above the upper limit the Bourdon tube uncoils and the flapper is pushed away from the instrument nozzle, lowering the pressure exerted on the control-valve diaphragm and causing the spring to close the valve. When the pressure in the inner bellows has dropped to that in the outer bellows, the opposing forces are once more equalized. This type of relay uses air only when the air-to-valve pressure is increased, consuming approximately 0.1 cfm. during an operating cycle. The instrument itself has a nozzle bleed of about 0.01 cfm. The air consumption of the entire unit is, of course, dependent upon the number of times the position of the control valve is changed within a given interval.

The on-off controller is one of the simpler types of pneumatic instruments, but there are others so complex and numerous that only passing mention can be made of them here. One of the reasons for their development was the desire for more flexible control than that offered by the former. Many refining processes require a valve with a throttling action which permits setting it at some point between completely open and completely shut. One of the first of the more intricate instruments to be designed was the proportional type which gives the valve a corrective movement with every change in the variable being handled. Thus, if the temperature of the liquid being processed increases slightly, the valve controlling the heat shifts correspondingly toward the closed position. The extent of its travel for a given change in the variable is not fixed, but can be adjusted by a so-called "proportional band" which makes it possible to convert an instrument from one of extreme sensitivity over a narrow working range to a unit of less sensitivity covering a much wider range.

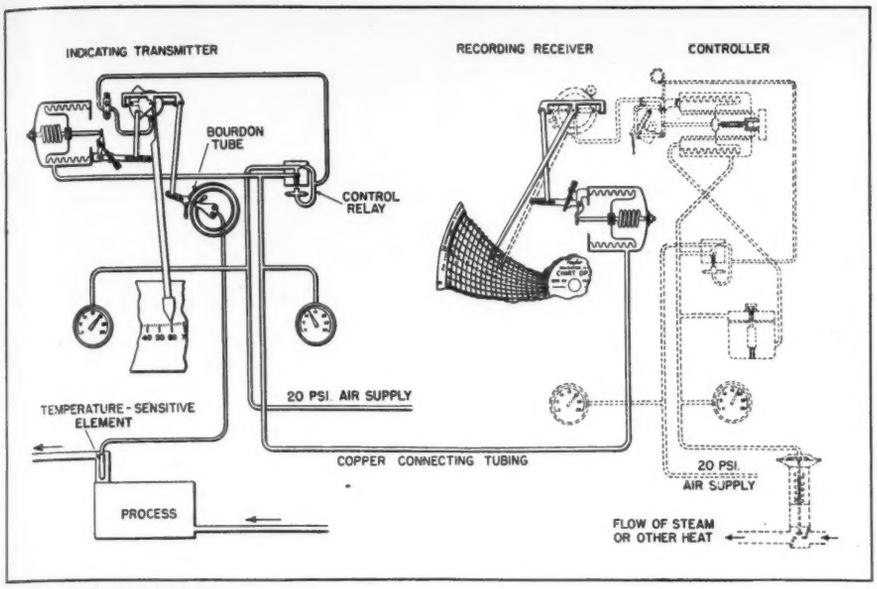
An additional feature was incorporated in many pneumatic controllers to offset the drift of the instrument pen from the control point that is caused not by changes in the variable being controlled but by changes in other variables such as in the amount of liquid passing through a system. Corrections of this kind are made by what is termed a "reset," which serves to bring the pen back to the control point continuously and automatically regardless of the degree of load change. Air-operated controllers can be equipped for still another function, known as the "derivative" function, which gives them a greater degree of control over a particular process than any of the types previously mentioned. Because of it, a sharp, corrective movement is imparted to the control valve the instant the pen leaves the control point, the extent of the movement depending upon the degree of change in the variable being measured. Some idea of the con-



FOXBORO COMPANY

MULTIPLE-CONTROL INSTRUMENT (FIGURE 2)

A pneumatic controller that incorporates all the additional features mentioned in the article. The bellows arrangement in the center is the main controlling unit, and the instrument pen and index marker are at the left. On the right of the controlling mechanism are the elements that can be adjusted to vary the sensitivity of the instrument. A greater or lesser degree of control over a process may be gained by varying the proportional band, the reset resistance, and the derivative resistance.



TAYLOR INSTRUMENT COMPANY

REMOTE-CONTROL SYSTEM (FIGURE 3)

Pneumatic transmission makes it possible to control process variables from a remote point. By means of a transmitter, the line air pressure is reduced or increased in direct proportion to the change in the process function being measured. Piped to a suitable location, the air actuates indicating or recording instruments and, where desirable, a controller. This eliminates the need of running lead lines containing corrosive, flammable, toxic, or otherwise dangerous fluids into the control room. The principal elements of a system for measuring temperature are pictured here. Temperature changes, transmitted in the form of gas impulses, react on a Bourdon tube which, in turn, relays them to a recording receiver where they are registered on a chart by the movement of a pen. The dotted lines indicate the apparatus that may be added to the receiver to control process temperature from a remote station.

struction of a controller incorporating these various features can be gained by reference to Figure 2, which shows one of the proportional type fitted for both reset and derivative functions.

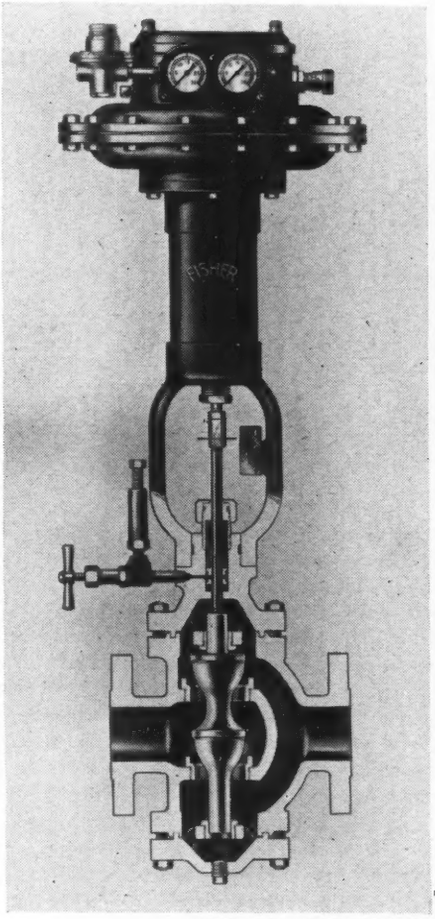
Refining processes may also be remote controlled, as shown in Figure 3. This is done by means of a transmitter mounted on the refining unit and of a receiver located in a central station. The receiver houses any one of the control instruments, with recorder or indicator, which have been described. The transmitter has a pilot mechanism similar to that used for automatic control and through which the distant control instrument is operated by air pressure, which varies in accordance with changes in the process variable.

Some idea of the many and varied applications of pneumatic instruments in a refinery may be obtained from the following information concerning a large catalytic-cracking unit recently installed in a midwestern plant. The number of instruments supplied for the control of temperature, pressure, flow, and liquid level totals 142 of which 88 are controllers and 54 recorders. They make up 38 panels in the control room, and more than 7 miles of copper tubing was used to connect them with their various working elements. When it is realized that so much equipment is needed for one unit of a modern refinery, the importance and scope of automatic control can be appreciated.

During recent years, the growing complexity of refinery processes and the ever-increasing scale of the operations have resulted in the construction of larger units and heavier mechanical equipment. This has presented new problems in valve design, because the power exerted by the ordinary air-operated diaphragm is not sufficient to overcome the inertia and friction inherent to large slide valves, butterfly valves, and other regulators such as are now used. Most of the newer catalytic-cracking plants control the flow in pipe lines by slide valves often 3 feet and more in diameter and weighing in the neighborhood of 9 tons. Obviously, auxiliaries are required to move them. Work of this kind is mostly done with air power. A unit of this type is shown in Figure 4. It is supplied with compressed air not only from the controller but also from an additional source to move the piston connected to the valve or other regulator.

So much in evidence are the instruments themselves that they often overshadow an important part of any pneumatic control system—the air that makes it work. Fundamental requirements of the compressed air used for this purpose are: reliability of supply, cleanness, and dryness. Most refinery operations are carried on 24 hours a day seven days a week for a considerable length of time between shutdowns, so that compressors must be run continuously. Interruptions caused by air failure may cause products made during such periods to be rejected as worthless.

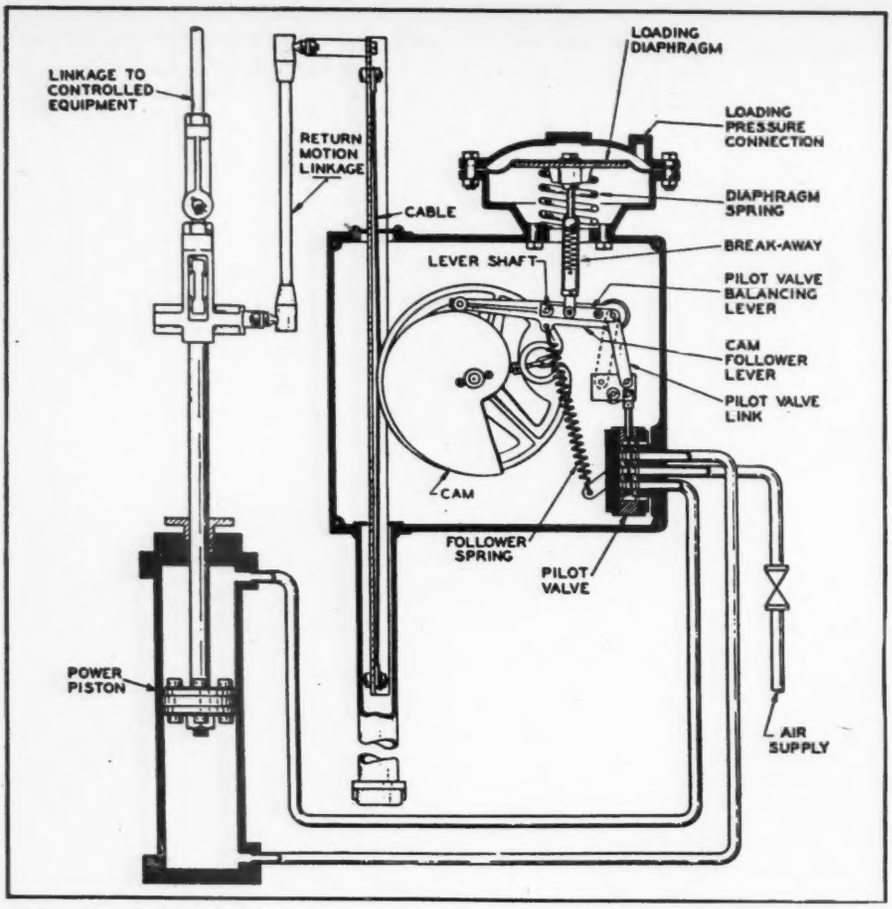
As most refineries use air for purposes other than those described, the supply for the control instruments may be tapped from the lines of the main compressor plant. If that is done, however, care must be exercised that the total demands on the system at no time are such as to deplete the supply to a point where the pressure falls below that necessary for the operation of the controls. In order to minimize this danger, small stand-by compressors may be installed near the instruments. These machines are arranged so as to cut in



FISHER GOVERNOR COMPANY

COMPLETE UNIT

Not all instruments are remote controlled, for often a process does not have to be watched constantly. Shown here is a complete control unit that can be interposed in a pipe line to regulate the line pressure. When connected to a measuring device in the line, the air-operated controller mounted in a case on top of the diaphragm chamber of the control valve exerts a throttling action on the valve to control the pressure in the line. The control valve of the instrument may be set at any desired value, and the unit will then require no attention except an occasional check. Control valves may be of either the air-to-open or air-to-close type. The former is the most widely used because it automatically closes and shuts off the flow in case of failure of the air supply to the instrument. The unit shown is of the air-to-close type.



REPUBLIC FLOW METERS COMPANY

PNEUMATIC POSITIONER (FIGURE 4)

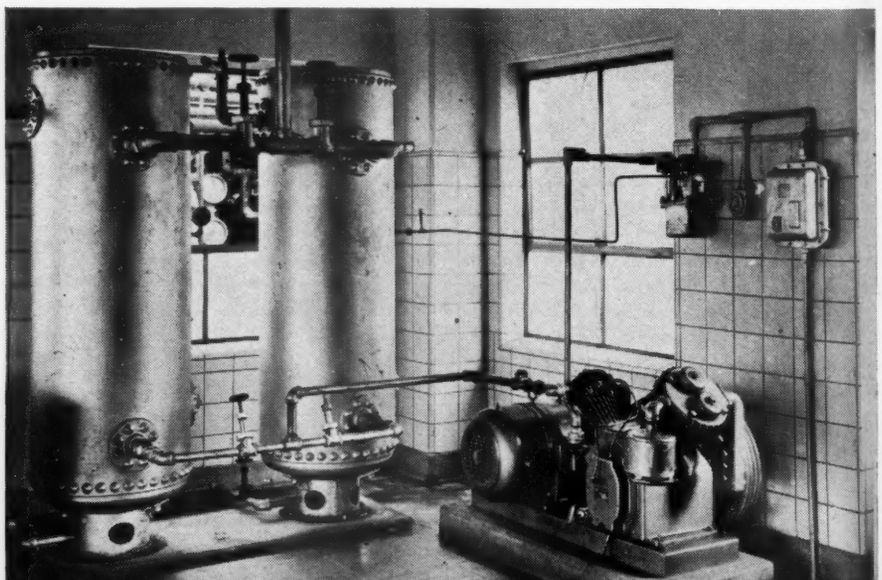
This device eliminates the need of mechanical linkage between it and the control element (such as a valve) which it operates. Air from the controller is admitted to the instrument through a loading-pressure connection. When the loading pressure is zero, both the power piston and the loading diaphragm are in the up position. An increase in loading pressure causes the diaphragm to move downward and to actuate a pilot valve to admit air to the top of the power piston and to vent it from the bottom. The resulting down thrust of the power piston gives the compensating cam a counterclockwise movement. As it rotates, the left end of the cam follower lever travels downward while the right end moves upward, returning the pilot valve to the neutral position and stopping the power piston just as it reaches a new position corresponding to the increased loading pressure.

automatically when the pressure in the instrument lines falls below a predetermined point.

If desired, a separate plant may be provided to serve the controls. Besides the main compressor, it would require a stand-by unit, an aftercooler, a separator, and drying equipment. Or, individual systems of a similar but smaller type may be set up for each processing unit or area. Apparently, a separate installation is the most dependable source of supply for control instruments.

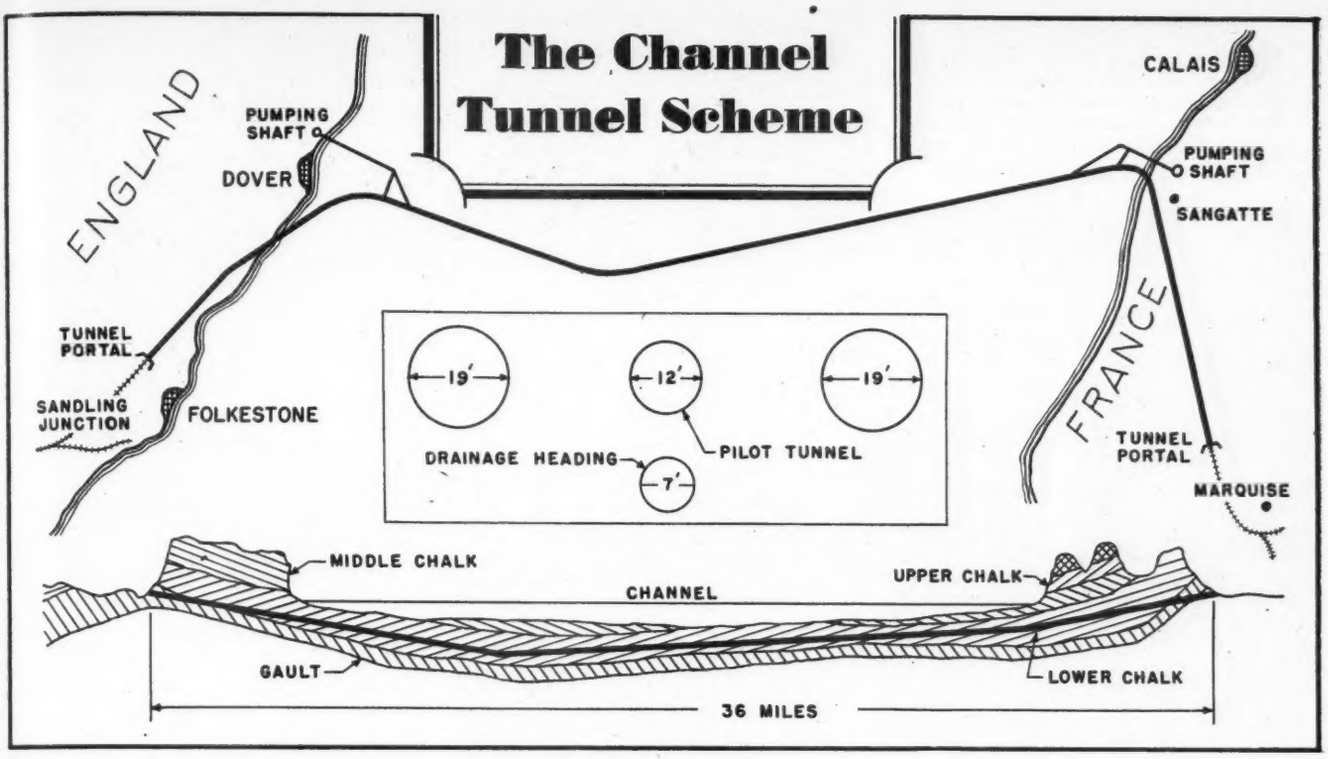
Foreign matter such as solids must be removed from the air to insure continuous, trouble-free instrument operation. Solids that may plug nozzles, restrictions, and pilot valves, and that may result in complete stoppage of a controller can be segregated by installing a filter on the intake of the compressor. Minute specks of oil are nearly as harmful because, aside from gumming up moving parts and generally causing an instrument to function erratically, they will plug tiny nozzles and orifices as readily as will solids. It is therefore essential that the air be cleaned by passing it through a separator on its way to the instrument. Another method by which oil-free air may be obtained is by the use of nonlubricated compressors in which graphitic-carbon piston rings prevent metal-to-metal contact of the piston with the cylinder wall.

As to the third undesirable element, moisture, its presence in a pneumatic control system has many harmful effects both in the distribution lines and in the apparatus themselves. Moisture is present to varying degrees in all compressed air, and if not removed or reduced to a minimum will cause trouble by freezing during cold weather and by rust, scale, or corrosion in the instruments or supply lines. Most refineries are equipped with aftercoolers to condense and separate moisture from the air, and these are often supplemented by driers to dehumidify the air before it enters the control units. Altogether, considerable pains are taken to furnish an adequate supply of clean, dry air, forming as it does the very lifeblood of the control systems which enable the refinery to convert the crude-oil fractions into the products which, in turn, are the lifeblood of our highly mechanized age.



SOURCE OF AIR SUPPLY

Compressed air for actuating control instruments may be taken from the regular plant distribution system or supplied by one or more separate compressors stationed near control centers. A machine of the latter type—an Ingersoll-Rand Type 30 air-cooled, motor-driven unit—is illustrated.



THE 1930 TUNNEL PROPOSAL

This plan was recommended by a group of British engineers in 1930 and is the basis of the current discussions looking towards the revival of the much-debated project. Of the 36 miles of tunnel, 24 would be underwater. More than 7000 samples of the seabed, taken in 1875-76, indicate that the lower (gray) chalk formation is continuous underneath the waterway and sufficiently impervious to be bored without presenting a serious pumping problem. The cross sections show the two main tubes, a pilot bore between them, and a drainage gallery at a lower level.

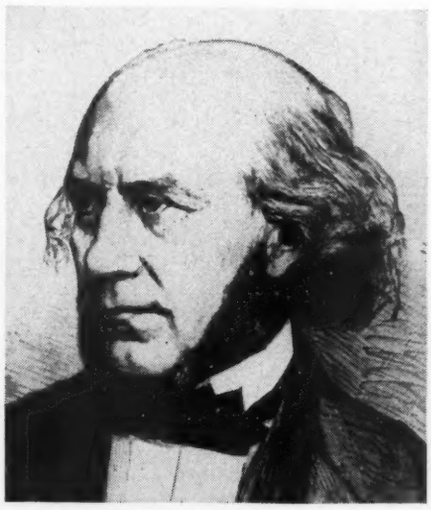
Underwater Tube Between England and France, First Proposed in 1751, is Again Under Discussion

G. J. Constantini

FRENCH and British engineers and members of Parliament have recently begun meetings in London to discuss a very old scheme. These talks constitute the latest chapter of a long story that started nearly 200 years ago when a French engineer named Desmarets made plans to connect England with the European Continent. His proposal was followed by dozens of others, but at first nobody paid serious attention to those "foolish ideas." Before long, however, both the French and British governments realized the importance of the project as a means not only of intercommunication but of promoting trade.

Diplomats and technicians were in agreement regarding the matter, but met strong opposition from the Committee for Imperial Defence which alleged that the Channel was England's main protection against attack from the Continent. On the seas, the Royal Navy was strong enough to stop any landing force, thus making a b'g standing army nonessential. However, the establishment of a permanent link between France and England would necessitate taking military precautions that would not only involve heavy expenditures but be an open door to trouble.

After several years of heated discussions, the Committee prevailed mainly because poor relations, attributable to tough colonial competition, divided the two nations. Such was the situation at the end of the nineteenth century. But since then the picture has changed completely. It has two aspects. On the one hand, France and England have at last grasped the fact that, if they are to serve their own interests, they must coöperate to the fullest extent, and the two wars they fought side by side have helped much to develop mutual confidence and friendship. On the other hand, in this atomic age, the Channel can no longer be expected to safeguard Great Britain and is, in fact, an obstacle that should be overcome as soon as possible for the betterment of commercial relations among European nations.



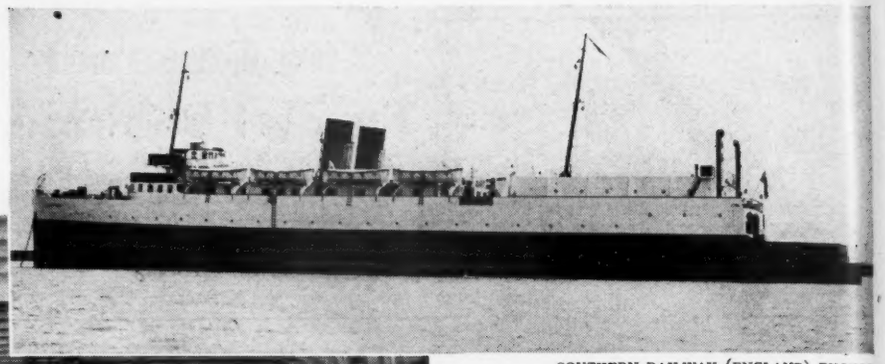
THOME DE GAMOND

He spent 40 years studying the channel-tunnel problem and died in 1876 without money and virtually unknown.

At the present time, travelers crossing the Channel between Calais and Dover, Dieppe and Newhaven, Boulogne and Folkestone, Le Havre and Southampton have to leave their trains upon reaching the coastal points and continue their journeys aboard small boats. However, by using the Dunkirk-Dover Ferry-Boat Service they can avoid transfer and remain in their compartments throughout the entire trip. The latter transportation system was first tried during World War I in order to expedite the movement of troops and goods from England to the French battle-

DOVER-DUNKIRK FERRY

The "Twickenham Ferry," one of three 500-foot boats that accommodate complete passenger trains between Dover and Dunkirk. The view below shows the four tracks on the lower deck on which the cars are run.



SOUTHERN RAILWAY (ENGLAND) PHOTOS

fields and gave very satisfactory results.

Interrupted in 1919, the service was resumed in 1936, and now three ferryboats, owned by the British Railways Company, run every night both ways between England and the Continent. These vessels are about 500 feet long, and each has four tracks on the lower deck for a complete train. At full load they can cross the Channel in five hours. Actually, this ferry service is not popular with the public and was organized mainly to transport fruits and vegetables from southern France and Italy to London's food markets. Bulky and heavy freight is carried on regular merchant ships, which sometimes take weeks to make the run.

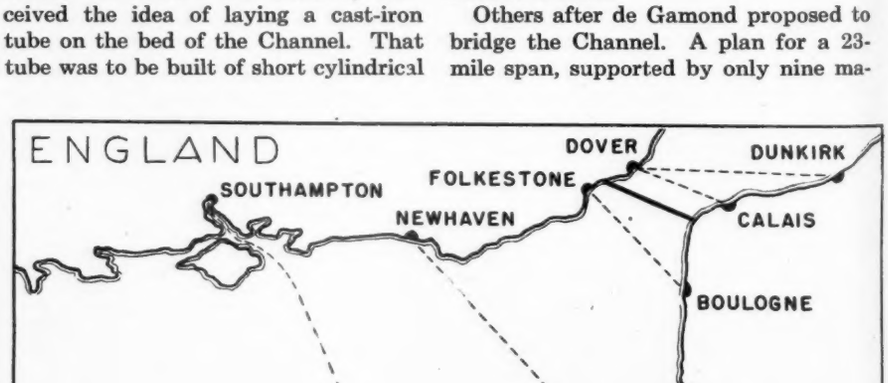
Of the five passenger lines between England and the Continent, the Calais-Dover route is the shortest and most comfortable. However, all are unsatisfactory because they expose travelers to the discomforts of seasickness in rough weather. In an effort to overcome this disadvantage and otherwise to improve cross-channel communication, various schemes have been suggested during the past 200 years by French and British technicians.

In 1751, Desmarets laid before the Academy of Amiens a plan for a tunnel under the Straits of Dover. His project had no technical value, but was developed 50 years later by a Mr. Mathieu who proposed to drive two superimposed galleries sloping gradually downward from the center. The lower one was to be used for drainage purposes and the upper for horse-drawn traffic. Both were to be lighted by oil lamps and ventilated by means of iron tubes extending above the surface of the sea. That proposal did not take into consideration the geological formation of the Channel and was therefore impractical. However, when brought to the attention of Napoleon Bonaparte by Prime Minister Fox, to whom it was submitted in 1802, the former declared: "That is one of the great things we (France and England) could do together."

Engineers do not give up easily, and numerous other interesting schemes followed. In 1803, a Mr. Mottray conceived the idea of laying a cast-iron tube on the bed of the Channel. That tube was to be built of short cylindrical elements and surrounded by masonry and other heavy material to hold it in place and to enable it to withstand the tremendous water pressure to which it would be exposed. Mottray's plan was improved upon by Thomé de Gamond in 1834, Franchot and Tessier in 1846, John Bateman in 1869, and by an Italian engineer in 1930. Each claimed that his tunnel would provide a safe link between French and British railway systems. However, that was not the opinion of the two Parliaments, which rejected all the proposals as dangerous and impractical.

Thomé de Gamond, a leading advocate of the cross-channel project, subsequently suggested several schemes before undertaking his famous tunnel studies. He successively thought of building a submerged archway on the bottom of the Channel, the work to be carried out with the help of submarine boats of his own invention; an artificial isthmus across the Dover Straits; and a bridge, with a superstructure 150 feet above sea level, connecting Calais and South Foreland.

Others after de Gamond proposed to bridge the Channel. A plan for a 23-mile span, supported by only nine ma-



CROSS-CHANNEL FERRY ROUTES

Although there are five ferry services between England and France (dotted lines on map), none is popular because of seasickness induced by the roughness of the channel. The solid line indicates the approximate location of the proposed tunnel.

EXPERIMENTAL BORE

This recent picture of a section of experimental tunnel driven from the British coast around 1880 shows the unsupported chalk walls to be in good condition after almost 70 years of exposure.

sonry piers, was submitted to the French Government by a Mr. Boulet. More recently, in 1930, McDonald and Huguenin contemplated constructing a 22-mile bridge, with a clearance of 200 feet above mean high water, between Cape Grisnez and Folkestone. That structure was to rest on 81 piers, and the design called for 26 spans on the British side and 27 on the French side, each 2000 feet long, and a 4-track passing station midway supported by 29 spans of 450 feet each. The main deck was to carry a road and two railway tracks. All the spans were to be of the continuous suspension type with inverted 3-hinged trusses and cable wind trusses. For the safety of shipping, powerful lights were to be installed on every pier. The total cost of the project, as estimated by the originators in 1930, was $300,000,000. Though never considered to be impracticable, the main objection to a bridge was the obstruction the piers would offer to navigation in case of foggy or rough weather, and especially to vessels traveling with the tide.

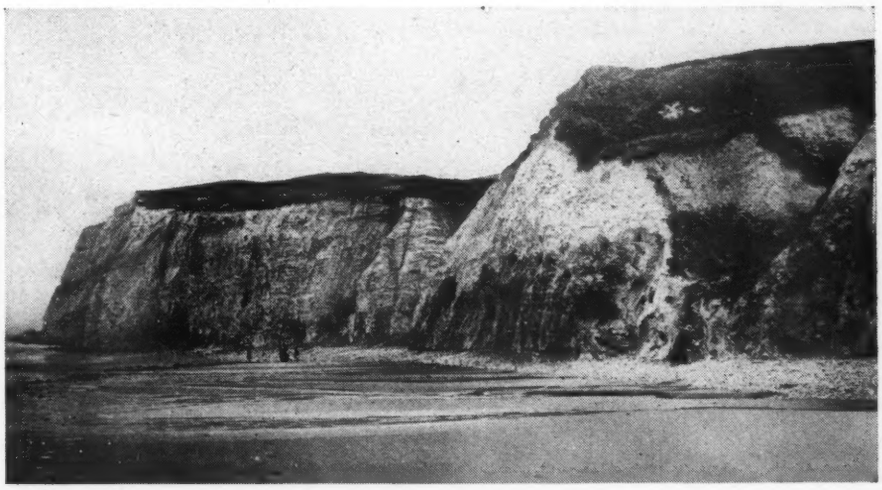
All the foregoing facts lead to the conclusion that the only satisfactory solution of the cross-channel problem is a subaqueous tunnel. As has been said before, Desmarets and Mathieu were the first to suggest linking England and France by a passageway under the bottom of the sea, but no serious attention could be paid to their proposals because they were not preceded by geological investigations. Thomé de Gamond was the first engineer on record to undertake a careful study of the channel-bed formation. In 1856 he planned to drive a tunnel from 26 shafts sunk through thirteen man-made islands in the Straits of Dover. Those islands were also to serve for purposes of ventilation and spoil removal and were to be blown up once the project was finished.

Running in a straight line between Cape Grisnez and Eastware Point, the bore was to have an inside diameter of about 22 feet, sufficient for two railway tracks and a tube beneath for drainage water to be handled by pumps installed on both coasts. In the middle of the Straits, on the Varne Sandbank, de Gamond intended to create an artificial harbor with a tower connecting the tunnel with piers to permit the transshipment of goods. All the work was to be completed in nine years.

It is a well-known fact that France and Britain were linked by an isthmus thousands of years ago. Under the erosive action of the sea, that neck of land slowly disappeared, giving way to what is now known as the Straits of Dover where the water is never more than 150 feet deep. De Gamond noticed that the cliffs on both sides of the Channel were identical in formation and tried to ascertain by numerous soundings whether the chalk beds continued underwater.

To bring back samples from the bottom, de Gamond submerged 100 feet or more without equipment, a depth at which he was subjected to terrific pressure. Because he could not hold his breath for more than 90 seconds, heavy weights were fastened to his feet to accelerate the dive and were released by him when he was ready to come to the surface. As a result of those explorations, de Gamond decided, in 1866, to have his tunnel driven through the Wealden Formation located directly beneath the layers of chalk and gault. Later on his choice proved to be wrong mainly because of the danger of water infiltration.

Nevertheless, de Gamond's scheme was received with great interest in England, where two engineers—Sir John Hawkshaw and William Low—began to study the problem. Hawkshaw, with the help of Henri Brunel, continued the work started by the French engineer. To check the nature of the strata composing the sea bed, Hawkshaw designed a special apparatus weighing approximately 100 pounds that could cut cores 6 inches long and 1 inch in diameter. By this method he made numerous borings throughout Dover Straits and was able to determine the nature of the various underlying formations and select the one through which a tunnel could be driven. Ten years later, his conclusions were confirmed by Potier and de Laparent who, in 1875-1876 took more than 7000 soundings within an area of 200 square miles. Those investigations

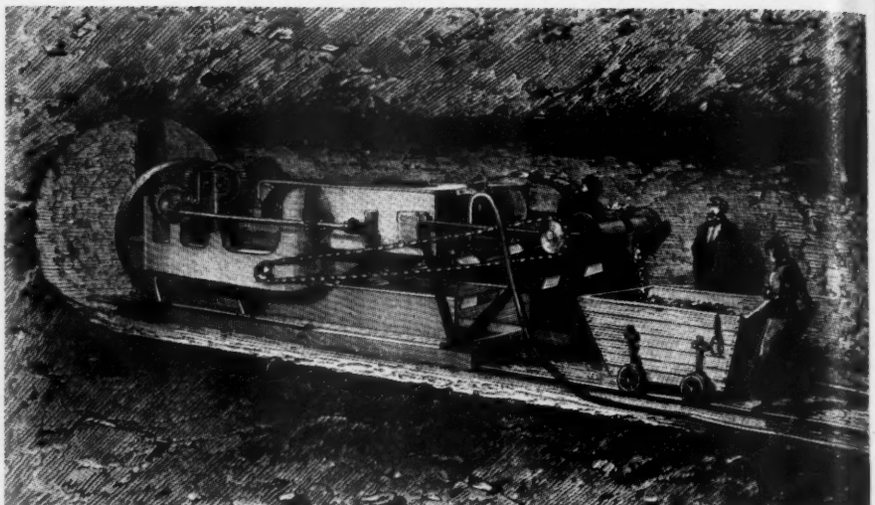


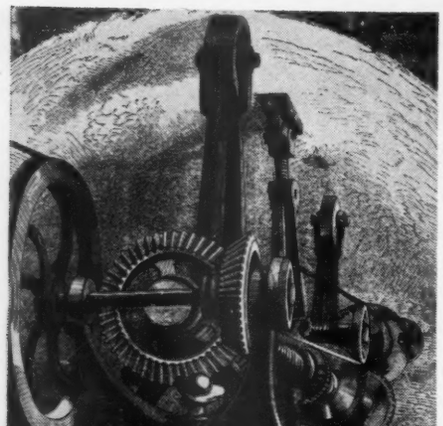
CHALK CLIFFS

View along the French coast where the bed of chalk disappears underneath the sea. Geological investigations have proved that the chalk formations common to both France and England once formed a connecting isthmus through which the sea cut a channel known as the Dover Straits.

TUNNELING MACHINES

Most successful of the several air-operated rotary chalk-cutting machines developed in the 70's and 80's was the one developed by Col. F.E.B. Beaumont (right). Cuttings sheared off by the revolving head were conveyed to the rear of the 24-foot unit and dropped into a muck car. That machine advanced up to 70 feet a day in the soft ground and excavated 1½ miles of 7-foot-diameter tunnel without developing serious trouble. Another machine of the same era (below), designed by M. Brunton, was tried but discarded.





proved that the lower stratum of so-called gray chalk was suitable for tunneling. This rather soft material lies right above the beds of marl and the Wealden Formation, is impervious, and has an average thickness of 200 feet.

While Hawkshaw proceeded with the geological studies, William Low, with de Gamond's help, drew up a plan for twin tunnels connected by cross passages. That design did not meet with Hawkshaw's approval, and the resultant disagreement between the two engineers led to the formation in 1872-1873 of two rival companies—the Channel Tunnel Company defending Hawkshaw's single tube, and the Anglo-French Submarine Railway Company backing Low's idea. On the continent, the French Tunnel Company was organized in 1875 under the direction of Michel Chevalier and with the sanction of the French Government.

After preliminary soundings by Potier and de Laparent had convinced the French Company of the feasibility of the project, it decided to sink a shaft at Sangatte near Calais and to drive an experimental heading through the lower part of the gray-chalk bed. Sinking of the shaft took a long time because water, encountered while passing through the upper formations, had to be pumped out and fissures sealed with cement. When some 200 feet underground, the expected chalk was reached and tunneling started immediately.

Being very soft, the material could have been excavated without special equipment, but a drilling machine was put in service to facilitate operations. Developed for the purpose by Col. F. E. B. Beaumont, the machine was 24 feet long and designed to drill a hole 7 feet in diameter without the use of explosives. It had two 12-inch-diameter air cylinders with 18-inch-stroke pistons by which the crankshaft was driven at 100 rpm. Through a combination of gears, the speed was reduced to 1½ rpm. at the tool block.

The drilling head itself was nothing more than a heavy structure with a number of steels set in the working face and acting as cutters. Given a rotary motion, these blades cut the chalk. The broken material was received in two compartments in the back part of the cutter head, transferred mechanically to buckets at the rear of the machine, and loaded directly into cars. The assembly was mounted on a heavy chassis, and a hydraulic system controlled the necessary sliding and forward movements.

Later, M. Brunton constructed an excavating machine which was used to drive a second experimental gallery. Also powered by compressed air, it had a drilling tool made up of three disks equipped with cutting steels. The disks revolved at a determined speed on their own axes and, at the same time, moved slowly around the machine's central shaft. Power transmission was effected by a complicated planetary system of gears, thus making the equipment unfit for the work. In fact, after a few trials, Brunton's invention had to be rejected.

Beaumont's machine, on the other hand, gave very good results and drilled up to 70 feet per day. To supply the air required to operate it, the French Tunnel Company constructed a plant at Sangatte and installed four single-cylinder, water-cooled, stationary compressors. Three of these units could deliver a total of 88 cfm. at 113 psi.; but when lower pressures were adequate, the four machines, working simultaneously, furnished up to 350 cfm. Each cylinder had an internal diameter of 16 inches and a length of 30 inches, and all were connected through gears to a steam engine that developed approximately 150 hp. The Sangatte heading was advanced a distance of 1½ miles without encountering any serious trouble.

Around 1881, the Anglo-French Submarine Railway Company, with the sanction of the British Government, started experimental work at Shakespeare Cliff in England. The heading, which was driven with the aid of another Beaumont machine, was 6000 feet in from the portal when, by a Parliament order dated 1883, the project had to be stopped. With diplomatic relations between France and England growing tense, the French Tunnel Company also was obliged to close its Sangatte gallery, thus losing the results of eight years of effort. Three years later, the two British companies merged under the name of The Channel Tunnel Company Limited. Since then, attempts have been made every five or ten years to revive the old scheme, but so far all have failed.

In 1929, however, a group of British engineers, after a careful study of the whole problem, presented conclusions to a Committee of the Economic Advisory Council that do not differ much from those made some 60 years previously by de Gamond, William Low, and Hawkshaw. Their report, published in the form of a Blue Book, was submitted to Parliament in 1930 and brought out the following points:

Geological evidence shows that the Channel Tunnel should be driven through the lower bed of gray chalk. The 7000 soundings made by Potier and de

Laparent in 1875 prove that the formation continues under the Straits of Dover. Any fissures and unfilled valleys that might be encountered on the way, unless of exceptional size, could be sealed without much difficulty by cementation.

William Low's plan for twin tunnels should be followed, as it appears to be the most suitable. However, work on the main tubes should not be begun until a pilot heading, with an inside diameter of at least 12 feet, has been driven from coast to coast. Once finished, that bore could be used for spoil removal and ventilation. The heading would, of course, be advanced along the line of the proposed traffic tunnels, with radial holes drilled at short intervals to check the surrounding ground.

A 7-foot-wide drainage gallery sloping down from the center of the Straits to both shores should be driven simultaneously to permit discharge by gravity and be connected at frequent intervals with the pilot bore. The work of excavating the pilot and drainage galleries should take approximately five years, and the entire project could be completed in eight. For reasons of safety, the drilling machines should be operated by compressed air, and no explosives should be used in removing the chalk. The spoil could be hauled out in cars or reduced to a slurry and pumped into the sea. The latter suggestion, if practicable, would save considerable labor, time, and money.

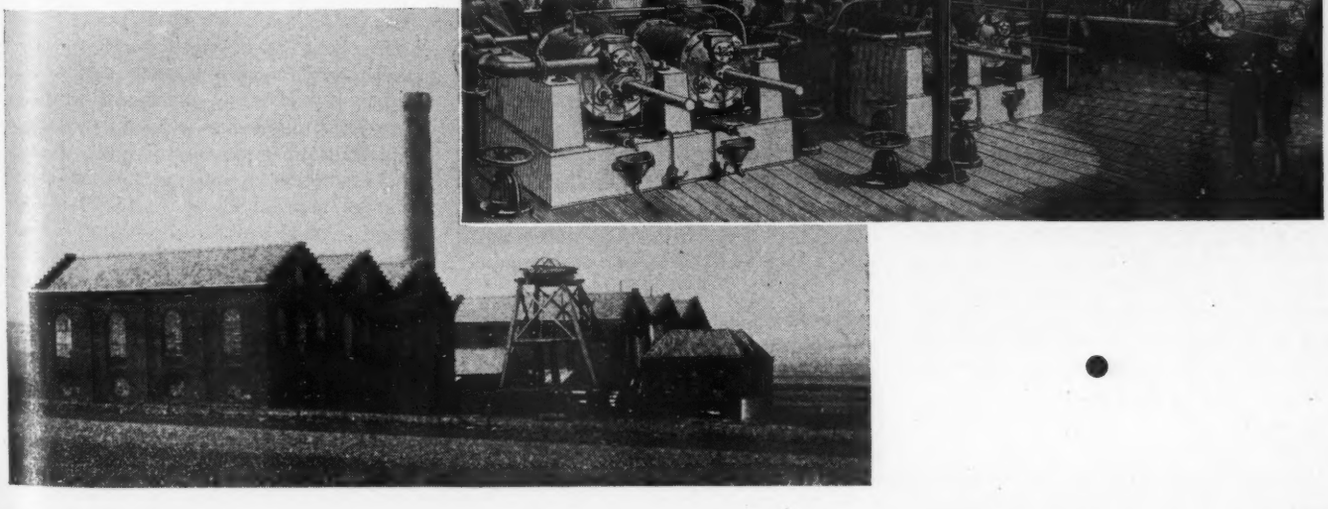
The traffic tunnels as proposed in the 1930 Blue Book have a total length of 36 miles of which 24 would be under the channel bed. The location of the French portal is close to Marquise, midway between Boulogne and Calais, while that on British soil is on the outskirts of Folkestone near Sandling Junction a few miles west of Dover. Each tube has a diameter of 19 feet to give railway cars free passage. The trains would, obviously, be driven electrically through the tunnels, generating stations to be built at each end providing the necessary power. Movement of the trains themselves should create sufficient ventilation that could be regulated by openings in the pilot bore. Continental railroad cars are slightly wider than British ones, but this difficulty could be overcome by constructing special rolling stock that could run on either system. As to maintenance and operation, the pilot gallery between the twin tubes would be available at all times for the transportation of inspection squads.

In 1930, the total cost of the undertaking, including the two power stations and sufficient rolling stock, was estimated at approximately $150,000,000. Now, with the tremendous increase in the cost of labor and material, the expenditure involved would be, say, $250,000,000 and more. With the progress made meanwhile in tunneling practice and drilling machinery, it should not take more than five or six years to complete the project.

The French and British railway companies have computed that the route would carry at least 3,000,000 persons a year. Assuming that the rates would not exceed 80 percent of the present sea fares, passenger traffic alone would bring in an annual revenue of more than $10,000,000. Transportation of baggage and light freight would account for another $6,000,000. About 20 percent of the income would go to maintenance and operating cost, leaving a yearly profit of $12,800,000.

The work could be carried out by private enterprise with the financial assistance of both the French and British governments. It would give employment to 4000 men for a period of at least five years. The interests of the concerns engaged in the short sea trade would, of course, be affected by a cross-channel tunnel, which would probably carry most of the light freight. However, heavy and bulky goods could not be diverted to it and would still have to take the much slower but cheaper water routes. Under the circumstances, competition between shipping and railway companies should not constitute an insurmountable obstacle to the construction of the twin tubes, and military and political objections to the scheme are no longer valid.

The establishment of such a link of fast intercommunication between the British Isles and the Continent would be of inestimable value both from the standpoint of trade and European economy. Perhaps the present discussions will bring to fruition the 200-year-old project on which so many men have spent much time and effort.



1875 COMPRESSOR PLANT

Reproductions of old prints of the exterior and interior of the French Tunnel Company's compressor plant built at Sangatte, France, to provide power for the Beaumont tunneling machine. Four single-cylinder compressors were driven by a 150-hp. steam engine. Working simultaneously, they delivered a maximum of 350 cfm. The structure was razed in 1926.

Regirdering a Railroad Bridge in India

AN INTERESTING construction project involving a single-line railroad bridge has recently been completed in India. The structure was converted into a double-track bridge with an overhead roadway and the work was done with only minor interruptions in rail traffic averaging 50 trains a day. First erected by engineers of the O. & R. Railroad and opened to service in 1885, the bridge crosses the Ganges near the city of Kashi (Benares), United Provinces. In its original form there was sufficient space on both sides of the single track to serve as roadways.

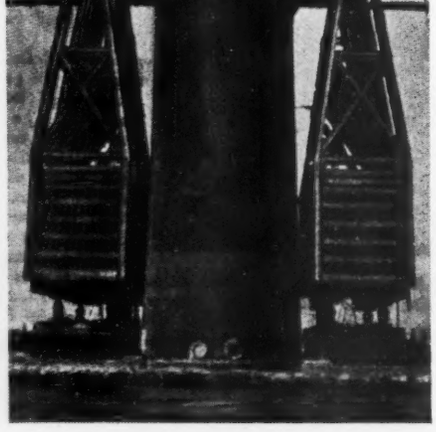
As the volume of traffic increased through the years, the carrying capacity of the structure became woefully inadequate, especially during the monsoon season when a rise in the river of 30-45 feet prohibited the use of a pontoon bridge just upstream. Accordingly, the East Indian Railway decided to redesign and reconstruct the span to enable it to meet present-day requirements. Work on the structure, formerly known as the Dufferin Bridge, was begun in 1941, but was soon interrupted by the war. Operations were resumed in October, 1945. The regirdered crossing, renamed the Malaviya Bridge, was officially opened to traffic on December 5, 1947.

The bridge consists of seven 350-foot main spans and nine 111-foot secondary spans, making a total length of 3449 feet. The original piers had been sunk to substantial depths below the stream bed —from 60 to 110 feet in the case of the main spans and from 70 to 160 feet in that of the others. Fortunately they were sound and of sufficient width to carry a double-line superstructure, necessitating only recapping to fit them for the new girders.

The first stage of the work entailed cutting down the tops of the projecting ends of the main piers to a point 11 feet 6 inches below the lower level of the old bearings. Air-operated tools were used for this purpose, and great care was taken so as not to damage the bridge supports. The masonry surrounding the bed stones underlying the bearings was prevented from shearing off by providing two reinforced-concrete walls tied together with 1⅛-inch rods. When enough space had been cleared on both ends of a pier, reinforced-concrete bed blocks 5 feet thick were cast in place as seatings for the new girder bearings. Following this, a reinforced-concrete band 5 feet high was poured around the top section of the pier, which was then ready to receive the girders. Recapping of the secondary-span piers was much easier. A band of concrete, 2 feet 8 inches top to bottom, was cast around each and the area surrounding the old bearings filled with reinforced concrete thick enough to serve as base plates for the bridge trestles.

Next came regirdering, which involved not only the installation of seven new main spans and nine secondary spans but the dismantling of the old superstructure. The old span between piers 6 and 7, on the side of the river opposite Kashi, was chosen as the assembly site, and there, on surrounding falsework, the main spans were erected, one at a time. All that could be assembled in this erection bay were the two trusses, together with top lateral bracings and sway bracings—in other words, the span without the railway and roadway floors.

As each span was ready, it was lifted approximately 10 inches by hydraulic jacks. A train of seven pairs of dollies, mounted on narrow-gauge track laid on the top chords of the old girders, was then run beneath it, and retractable beams housed between each pair of dollies were pulled out and positioned under brackets mounted on the verticals of the new span. That done, the jacks were lowered and the assembly brought to rest on the dollies, the leading pair of which was driven by electric motors. Weighing approximately 625 tons, the span was thus transported across the river and put in place on the recapped piers. This entire operation was carried out in three hours, between 7 and 10 a.m. Cross girders were then installed, the work being done from underneath to prevent further traffic interruption.



TESTING PIER STRENGTH

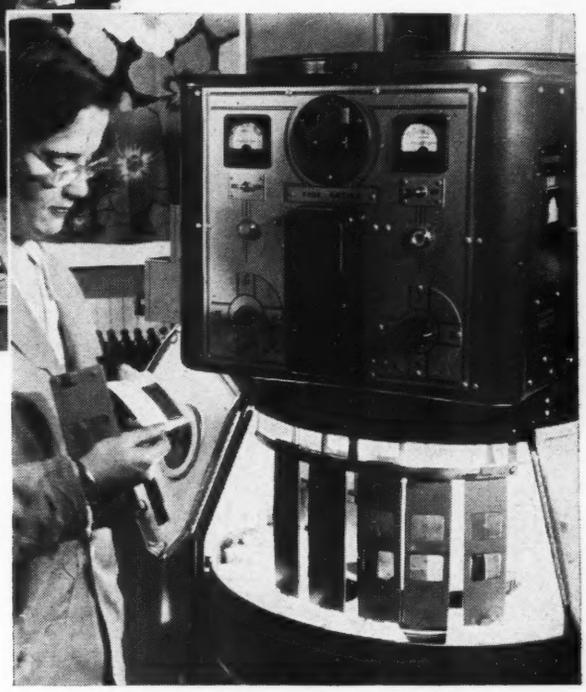
To determine whether the existing piers would carry the additional load to be imposed upon them, the test shown here was conducted. The one with the shallowest foundation was chosen on the assumption that it was the weakest. Weights equal to the estimated extra burden were suspended from it for 72 hours. The load did not cause the pier to sink into the river bed, proof that the support was adequate.

The load of the old span was transferred to the new one by lifting the former at the corners and lowering it onto blocks on the cross girders. The resulting camber of about 6½ inches destressed the old superstructure, allowing it to be dismantled with oxyacetylene torches and removed. After the roadway floor was laid, the railway deck was constructed by cutting away the old flooring and replacing it with two temporary stringers to carry the single track.

The secondary spans were completely assembled at ground level and loaded on open trucks running on broad-gauge lines laid parallel to the railway right of way. Each was moved to a spot directly opposite the one it was to replace, where it was raised by means of elevating trestles and transferred to trucks traveling on tracks run in a transverse direction. Between 7 and 10 a.m., during which traffic was blocked, the old span was lifted by two cranes, set on other trucks standing on the same transverse tracks, and moved out of the way. Permanent supporting trestles were then erected on the piers, and the new span was moved into position and transferred from the trucks to the trestles. The temporary rails carried by the new span on a set of stringer girders were next connected to the track on the adjoining spans. These operations took less than three hours, and one such changeover was made in the record time of 1½ hours. When all nine secondary spans were installed, the overhead roadway was completed and the temporary single rail line was replaced by permanent double tracks.

More than half a million rivets were driven in the course of the work. Each main span required 37,500 during its fabrication and an additional 30,200 after being moved into position. The painting of the completed structure was a big job in itself, involving the application of 220 gallons of red lead primer and 1700 gallons of aluminum finish.

It is of interest to note that the piers, built more than 63 years ago by what present-day construction men would consider well-nigh primitive methods, were found to be strong enough to support the heavier bridge erected on them. It was a feat of engineering in those days to sink piers to depths ranging from 60 to 160 feet and in a channel where the water varied in depth from 50 to 90 feet. Their permanency is a tribute to those early builders.



LABORATORY SCENES

Shown at the left is a section of one of the two floors that are devoted to fundamental research. Below is pictured a machine that intensifies and accelerates the effect of sunlight, enabling newly developed dyes to be tested for sunfastness indoors and under controlled conditions.

Looking Ahead with Research

A Staff of 400 Charts the Future Manufacturing Course of General Aniline and Film Corporation

Eugene Preston

RESEARCH has firmly established itself as a necessary and integral part of the manufacturing industry, and it bids fair to become even more important in the future. Higher levels of competition, together with ever-increasing scientific advances, demand that each industry keep abreast of the latest developments and trends in its particular field if it is not to drop by the wayside. Consequently, many concerns maintain full-time laboratories staffed by capable scientists and provided with the most modern facilities. As a matter of fact, many plants are often far better equipped in this respect than colleges and universities, our traditional strongholds of research.

Laboratories are normally not created overnight; rather, their personnel and equipment are built up over a period of years. Such was not the case, however, with the General Aniline & Film Corporation, for at the start of the recent war this large company was left with virtually no research facilities in this country. That it speedily established a full-scale laboratory, overcoming war-born shortages in materials and manpower in order to conduct research vital to our armed forces, is a tribute to its management and workers alike.

General Aniline & Film Corporation has had a long and varied history. Its record goes back to 1842 when Edward Anthony, a New York engineer and one of the first persons in the United States to learn the newly invented daguerreotype process, opened a photographic supply house at 308 Broadway, New York City. One of the early photographers who patronized Anthony was Matthew B. Brady, who became famous for his historic pictures of the Civil War. The Anthony firm, the old Grasselli Dyestuff Corporation of New Jersey, the General Aniline Works, Inc., of New York, and a number of other companies engaged in the synthetic organic-chemical business in this country formed the basis for the present concern.

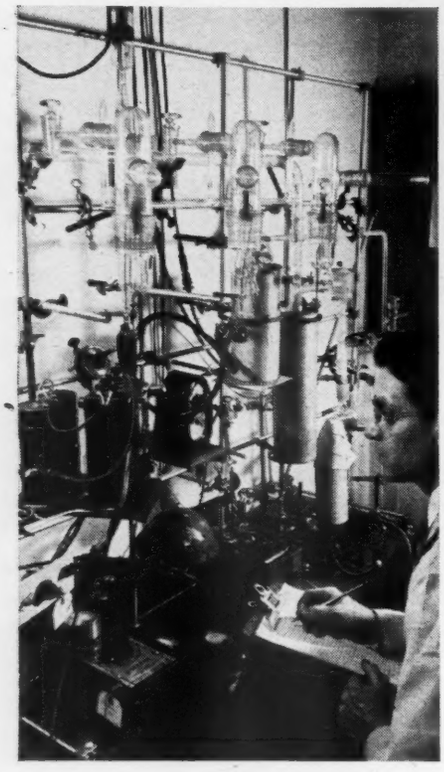
During the 1920's, the predecessor of General Aniline & Film Corporation was a participant in agreements and mergers that ultimately resulted in its ownership by the German chemical trust, I. G. Farbenindustrie. Under this control General Aniline was the recipient of patents and a wealth of technical data in the organic-chemical field, but all research was conducted in Germany. Following Pearl Harbor, one of the first acts of the United States Government was to take over the administration of General Aniline. An American board of directors was appointed to govern the concern, and its resources and facilities were at once directed towards furthering the war effort.

The corporation is divided into three principal manufacturing departments. The General Aniline Works Division operates plants at Grasselli, N. J., and at Rensselaer, N. Y., the latter being the oldest active dye factory in America. This division makes dyestuffs and intermediates, textile auxiliaries, household detergents, and numerous associated specialties. The Ansco Division, located in Binghamton, N. Y., produces amateur and professional films of all kinds, cameras and accessories, photographic paper, chemicals, and other kindred supplies. The Ozalid Division at Johnson City, N. Y., constructs a machine that combines exposure and development to reproduce facsimile copies of typed, drawn, or printed matter.

When ownership of General Aniline was transferred from foreign interests to the United States, government officials realized that its growth could be insured only by a constant flow of new ideas and experimentation. Accordingly, plans were made for the establishment of a research center to serve the corporation's

WITH THE AID OF VACUUM

Knowledge of the manner in which chemicals behave can sometimes be obtained only in a highly evacuated atmosphere. The scientist below is conducting an experiment with apparatus from which virtually all the air has been removed by a vacuum pump. The receiving flasks of the filters pictured at the right all have vacuum connections that reduce to minutes filtering operations that would require hours under normal atmospheric-pressure conditions.



three main divisions. No attempt was made to build a new and shining laboratory because the pressure of war needs demanded that it be set up quickly and with a minimum use of strategic materials. Instead, it was housed in a large concrete building, located in Easton, Pa., that had been a silk mill and was later used as a warehouse. The structure was ready for occupancy on October 12, 1942, and soon afterward a small group of chemists from General Aniline's plants arrived to form the nucleus of the present staff. Before the end of that month the laboratory was in operation.

As was the case with most other American manufacturing firms during the conflict, a large percentage of the products of General Aniline was directed to the armed forces or to plants engaged in turning out war supplies. Dyestuffs were needed for uniforms, tents, jungle cloth, boots and shoes, camouflaging materials, smoke signals, and the like. Synthetic detergents and organic chemical agents were produced for mildew- and waterproofing and for other purposes. Color, aerial, X-ray, and gun films were made for the armed forces, and the camera plant was converted for the manufacture of dead-reckoning and other precision instruments. The company also operated the only plant in the United States for the production of iron carbonyl, a chemical compound that provides an extremely pure form of iron used in radar and other electronic devices.

Because many of the dyestuffs and intermediates had been imported prior to the war, one of the first projects assigned to the central laboratory was that of identifying these substances and to solve any problems that might arise in connection with their manufacture. A notable achievement was the duplicating of a tackifier for synthetic rubber from a brief description of it taken from the enemy. Known as koresin, the compound was being used in Germany for the making of synthetic tires and was superior to anything available in this country. Scientists and workers discovered the secret of the tackifier in exactly nine days, and within 24 days sizeable shipments of it were on their way to major rubber companies.

At present, the two top floors of the 4-story building are devoted entirely to research. Here, in individual cubicles and surrounded by flasks, beakers, and other scientific apparatus, research men labor to develop new products and discover improved techniques. These investigators deal with the theoretical end of the business. Each project as it is received is assigned to one or more persons who will do the necessary basic research. Because this may require a series of experiments and tests extending over a period of several years, a written record is kept of all work done. When the assignment has been completed, samples made are turned over to other departments of the laboratory where they undergo further, more practical processing.

General Aniline, although a producer of a diversified line, is principally a dye-manufacturing concern. The company specializes in the more complex types such as vat dyes, acid-alizarine colors, and naphthols, as well as in their intermediates and auxiliaries. All these are required for textiles, paper, leather, plastics, paints, wood stains, inks, gasoline, and numerous other commodities. Nearly everything we see about us in our homes, offices, and elsewhere has been dyed or incorporates dyed materials, and the steady flow of new goods demands that much time and effort be spent in developing new dyestuffs to meet industrial needs.

Dyes that have originated in the research laboratory go to the dye-testing department where they undergo exhaustive investigation to make certain that they are satisfactory. Dyes for textiles, leather, and other products are tested by examining strips of materials for dye penetration, color fastness, and similar properties. The behavior of each dye when exposed to sunlight, water, and other conditions is checked to determine its suitability. Dyes for plastics are pressed into the compounds and subjected to similar trial runs. Color experts, men whose eyes have been trained by years of experience to detect minute tones and shades, compare the samples with established standards.

When a dyestuff or other substance has successfully passed its qualifying tests, there still remain problems of production. The chemical engineering laboratory on the first floor of the building is equipped to iron out these difficulties. Trials are conducted in that department or in small structures on the property to make sure that the quality

WASHING DISHES FOR SCIENCE

Housewives may shudder at this scene, but they will some day benefit from the prosaic chore. Greasy dishes are washed by the hundreds to test the effectiveness of synthetic detergents.

of an expensive dye is right before it is turned out in commercial quantities.

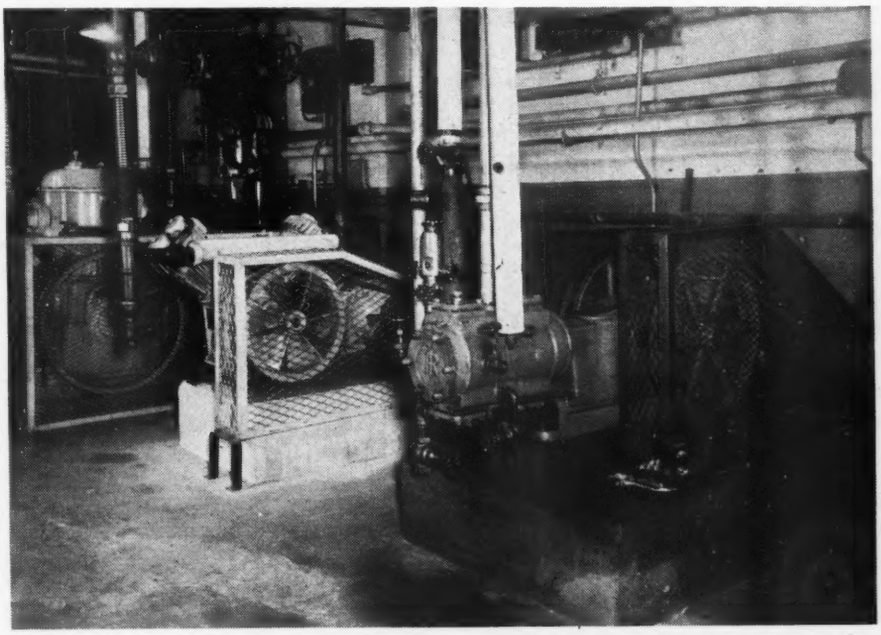
Compressed air and vacuum are of great aid to the investigators in their painstaking work, and piping systems make both available at many points throughout the laboratory. Dyeing of strips of cloth must be done under carefully controlled temperature conditions, and this is insured by air-operated instruments. Each workbench in the research section has outlets for air and vacuum. Where liquids of an explosive nature must be continually agitated, small air motors are a safe source of power; and blasts of compressed air are a quick and sure means of cleaning and drying beakers, flasks, and other chemical paraphernalia. Vacuum is of service in filtering solutions, for evacuating apparatus, and, in certain processes, for the removal of objectionable or poisonous gases. These are exhausted to the atmosphere by an arrangement of piping terminating on the roof in three auto mufflers, while condensed liquids are drained off at the bottom.

Every attempt is made to provide the research workers in the different departments with background material for each new project assigned, and the results of experiments are disseminated for the benefit of all concerned. A library on the second floor is stocked with technical books and current literature to keep the investigators abreast of new developments in their respective fields, and a conference room is available where complex problems arising in the technology of dye-making and other processes are discussed and the work already done is correlated to arrive at a solution. Analytical laboratories fitted with spectroscopes, physics equipment, and electronic devices make it possible for each scientist to obtain the basic information about the particular substance in which he is interested.

Because the activities of the different departments of the research center involve the use of much special equipment that would be difficult to procure from outside sources, a complete machine shop is maintained in the basement of the building. In addition to constructing apparatus of various kinds, it keeps the mechanical units of the laboratory in working order.

Approximately 400 persons are employed at the research center. As is the case with most companies engaged in the manufacture of chemical products, the staff is a highly technical one. Represented are 94 American colleges and eighteen foreign universities; and of its members, 66 hold doctors' degrees and 60 bachelors' and/or masters' degrees. The corporation is conducting a government-sponsored training program which qualifies participants for such positions as chemical-laboratory technicians, photographers, electricians, mechanical and chemical storekeepers, as well as glass-blowers. Both class-room and actual laboratory work are involved. The former is given under the supervision of a tech nically trained person in a local high school and in the conference room of the laboratory where such subjects as mathematics, organic and inorganic chemistry, physics, distillation, and dye application are taught.

Officials of General Aniline are convinced that its future depends to a great extent upon research and that the enviable position of American chemistry can be maintained only through the whole-hearted support of comprehensive research programs. This attitude on the part of the corporation is reflected in plans now underway for a new laboratory that will offer its staff facilities second to none.

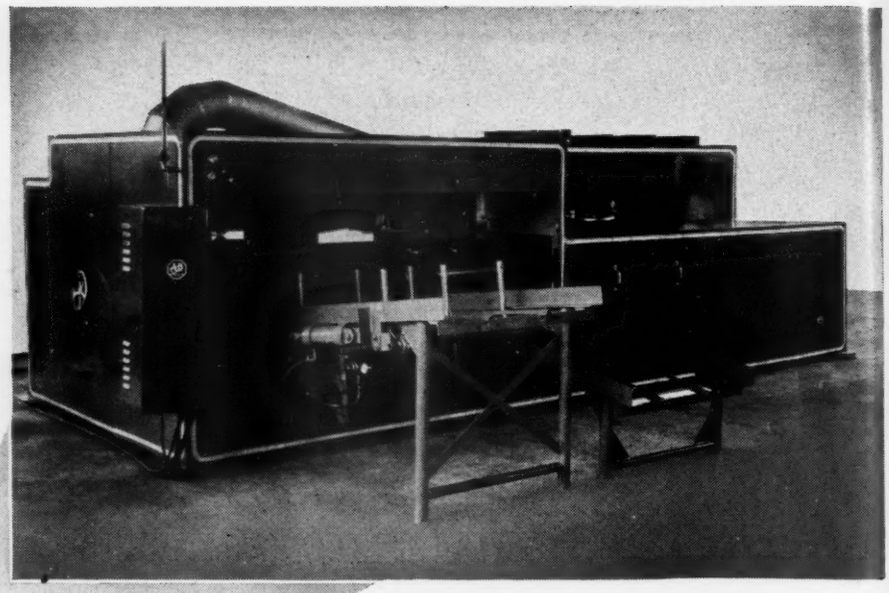


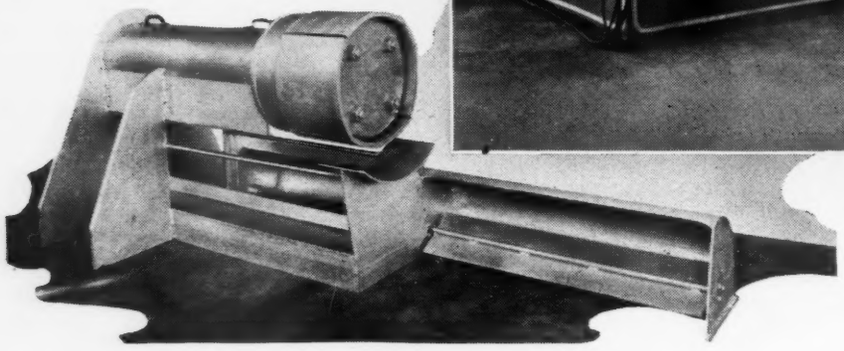
COMPRESSORS AND VACUUM PUMP

Two of these Ingersoll-Rand machines compress air while the third attenuates it. Piping extends from them to many sections of the laboratory.

DRUM RECONDITIONERS

At the right is the adjustable cleaning machine that works automatically including feeding of the drums; operation of the pneumatic ejector with which it is equipped causing a container to enter. However, the working cycle starts even if there is an interruption in the feed. Top and end brushes are affixed so that they reach down into dents and clean around bungs and chimes as they follow the contours of a drum. The air-powered, expansion-type dedenter shown below is 8 feet 3 inches long, 3 feet 2 inches wide, and 3 feet high. It rounds not only the bodies but also the ends of 55-gallon drums.





Reconditioning Steel Shipping Drums

STEEL drums battered in service may be reconditioned by machinery manufactured by the L. M. Gilbert Company. Included in this special line are a cleaner equipped with multiple brushes, a dedenting machine, a unit that cuts the heads from closed drums in a manner that permits their use with the same now open-end type drums, a combination flanger and beader, and a chime machine.

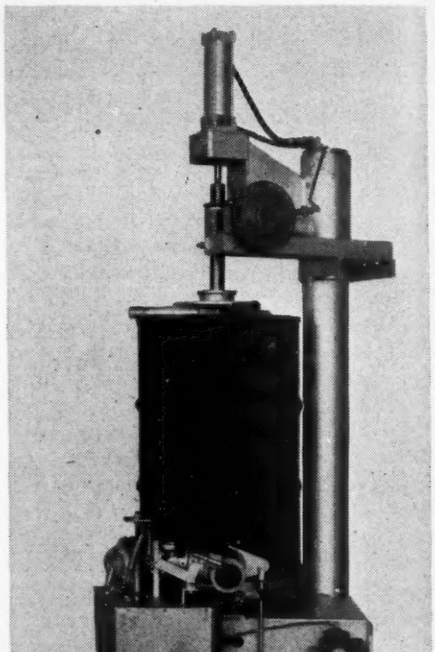
The cleaning equipment removes rust, scale, and dirt from 30-gallon, 55-gallon, and 100-pound-capacity containers preparatory to painting them. In one continuous operation it brushes and buffs the outer surface and ends of a closed drum or the inside and outside surfaces of an open drum. Each of the many brushes is driven independently and so suspended and tensioned that it follows the contours of the rotating container. The machine receives, cleans, and ejects the drums automatically, and may be fed continuously or intermittently. Its capacity is about 1200 in eight hours.

Cleaning is done in the dry state and the dust created is removed by a dust collector equipped with an exhaust fan driven by a 5-hp. electric motor. A 25-hp. motor furnishes the rotary power for the drums, and pneumatic cylinders are used to actuate the receiving, holding, and ejecting mechanisms. Combined, the latter require about 7 cubic feet of air per minute for continuous operation.

The machine designed to remove dents and other irregularities from open-end containers has an expansion head operated by a pneumatic cylinder using air at 100 pounds pressure and consuming 3.2 cfm. One after another, the drums are slipped over the horizontally disposed head which, as it expands, restores them to their original shape, sometimes with the aid of a mallet. The unit has a capacity of approximately sixty 55-gallon containers an hour.

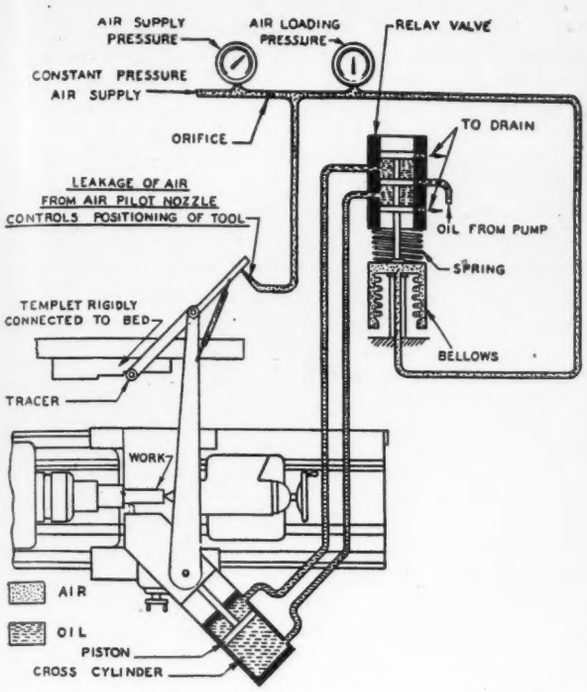
Deheading is done at a maximum rate of four 55-gallon drums a minute by a foot-controlled electropneumatic machine. Rotation of the container on the worktable is effected by a 1½-hp. electric motor, while the shearing wheel, the rolling wheel that bears down on the chime or edge during cutting, and the clamping device are actuated by air cylinders requiring about 4 cfm. when working at full capacity.

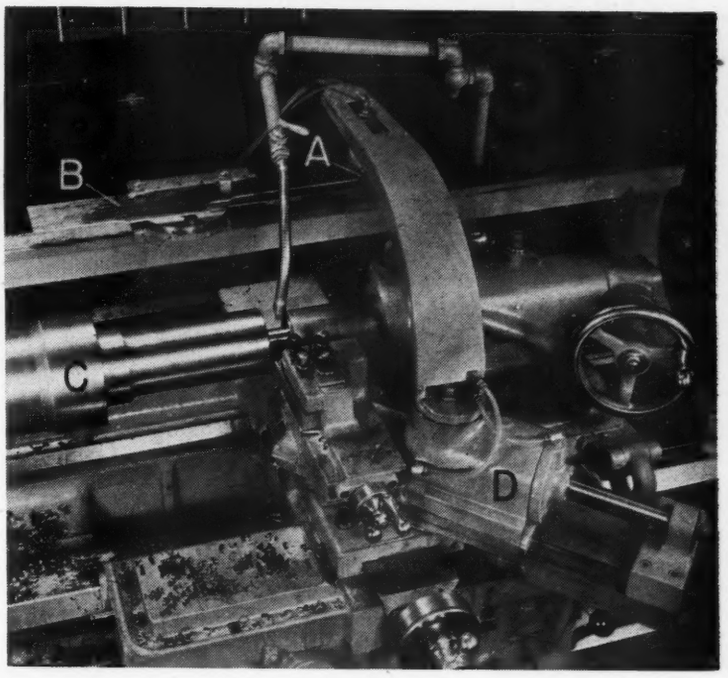
With the head removed from a drum it is necessary first to straighten and roll the chime—to restore it to its original round—and then to flange and bead or curl it. The unit that performs the last two operations is geared to function at the same speed as the deheader. It is hydraulically controlled with the exception of the chuck release, which is actuated by compressed air. The so-called chimer is an electrohydraulic machine which, by substituting a shearing wheel for the pressure wheel, can be adapted to cut off the head or bottom of a drum and at the same time straighten the chime.



DEHEADER

This machine is controlled by a foot pedal which successively admits compressed air to four cylinders to carry out the sequence of operations. One actuates a 3-armed chuck that holds the container firmly; the second moves toward the drum a rolling wheel that bears down on the chime during cutting; the third throws in a shearing wheel after the motor is started and the drum begins to revolve; and the fourth, by which time the pedal is fully depressed, clamps down the rolling wheel to maintain tension while shear separates head from drum in about one revolution.





AIR-TRACER INSTALLATION

At the right is shown a section of a Monarch engine lathe equipped with the new scanning device and turning an axle forging. Letters indicate: A, tracer; B, template; C, work; D, hydraulic cylinder on the tool slide. Ten diameters, seven radii, and two shoulders were machined on the forging in one hour. The diagrammatic sketch illustrates the operating features of the Model B Air-Tracer which has but one hydraulic cylinder. The tracer opens the pilot nozzle or valve which, in turn, regulates the air pressure in the bellows. A drop in pressure allows the spring to pull the relay valve down enough to force oil in the front end of the hydraulic cylinder on the tool slide, thus backing the tool away from the work. This continues until the pilot valve causes the air pressure in the bellows to increase sufficiently to return the relay valve to its neutral position, in which the oil pressure on both sides of the cylinder is equalized.

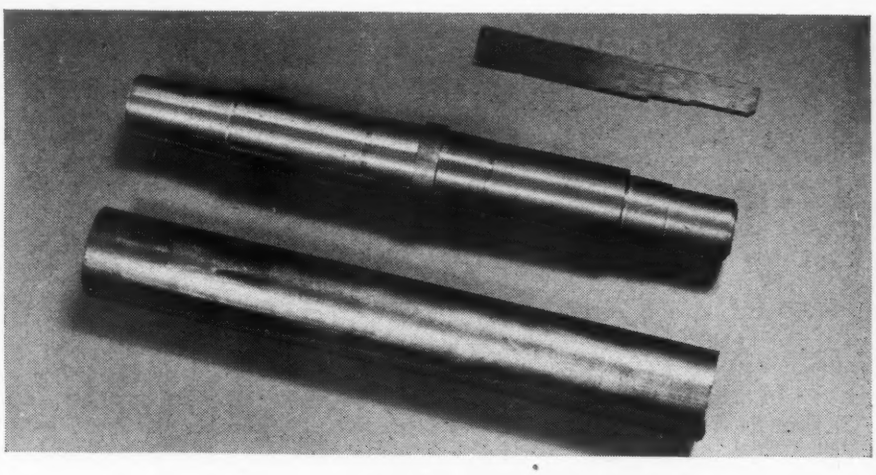
Air-Tracer Scans Contours in Machining Operation

TURNING, boring, and facing irregular contour work on lathes of The Monarch Machine Tool Company has been simplified by an air-scanning device originally introduced by The Bailey Meter Company but latterly improved upon by Monarch under an exclusive license from Bailey. The Air-Tracer, as it is designated, features a spring-loaded tracer that follows the contours of a pattern to be duplicated and controls the cutting tool of the machine by means of a hydraulic circuit. Either a master workpiece or template may be used, and the device will reproduce it within close limits.

The scanner works on the air-gauging principle. Compressed air at constant pressure is supplied to the system through an orifice of a size that is designed to maintain a pressure of 40 psi. when the mechanism is in balance. As a small amount of air is continually escaping to the atmosphere around the tracer valve, a film of air keeps the pressure in constant balance with no appreciable friction or pressure reaction.

Air-loading pressure established by the tracer controls the movement of the cutting tool by means of two hydraulic relay valves—a contour valve that regulates cross feed and cross traverse, and a feed valve that regulates longitudinal feed and longitudinal traverse. With the air-tracer valve in balance, the scanner operates with approximately 5 ounces of pressure against the template. The hydraulic relay valves are actuated through the medium of flexible, metal bellows which expand and contract in accordance with variations in air pressure. As the valve stems are attached to the free ends of the bellows, the movement of the relay valves is likewise determined by the air-loading pressure.

When the tracer is scanning a straight section of the template, the balance of the air-loading pressure in the contour part of the control system is undisturbed. Then the tool slide is locked in position because the hydraulic pressure on both sides of its actuating piston is equal. But the slightest change in template shape increases or decreases the air-loading pressure by changing the rate of flow



QUICK WORK

At the top is a template that was used in machining a locomotive link pin (center) from bar stock (bottom) in less than a minute by the aid of a Model A Air-Tracer. This was a record performance.

from the air-tracer valve. Instantly the movement of the tracer from its balanced position is amplified into hydraulic relay-valve motion in the ratio of 1 to 100. As the tool slide moves in the direction and to the extent of the template variation, restoration of balance begins but is not completed until the tracer again reaches a straight section of the pattern or template.

The accompanying diagram shows the Type "B" Air-Tracer, the model that was first introduced. It has but one hydraulic cylinder which controls the cross feed of the cutting tool. The tool slide is set at a 45° angle, and longitudinal movement of the lathe carriage is by the usual power or hand-wheel feed. The later Type "A," which has been broadly described, has two such cylinders: one controls cross movement of the cutting tool and the other longitudinal movement. Its slide is set at an angle of 90°, which permits maintaining a constant rate of feed on both increasing and decreasing contours, as well as on square shoulders. The rate of both cross and longitudinal feed is from ¼ inch to 15 inches per minute. The machining cycle is completely automatic—the slide withdraws at the end of the cut and the carriage returns to the starting position. The Type "A" Tracer is available for Monarch 10-inch precision manufacturing lathes and for all sizes of Model 60 engine and toolmakers' lathes.

High-Temperature Ceramic Coatings for Steel

AT AN early stage in World War II, when a shortage of nickel and chromium seemed imminent, the National Bureau of Standards began investigations with ceramic-coated steel as a possible substitute for nickel-chromium alloys in a number of high-temperature applications. This research led to the development of a new type of coating for mild steels that both laboratory and service tests have shown to be superior to conventional porcelain enamels under high-temperature conditions.

Initially used by the Army and Navy on certain aircraft and vehicle exhaust systems, the ceramic coatings have many peacetime applications. They have been used with success on baffle plates of continuous furnaces and on the inner cylinders of burner jackets for domestic kerosene stoves. Potential applications include parts of heat exchangers for marine and other turbine engines, annealing boxes, and mufflers and tail pipes for automotive vehicles.

Another recent application is as an exterior coating on large industrial tanks that are covered internally with ordinary porcelain enamel after sandblasting. Previously they were also sandblasted on the outside after firing to give them a clean surface for painting. By the new practice introduced, the tank is sandblasted only once, inside and outside, and the interior is then covered with porcelain enamel, while a ceramic coat is applied to the exterior. The latter also prevents oxidation of the steel when the enamel is fired.

Included among the outstanding properties that are ascribed to the coatings by the Bureau are: high resistance to chipping under repeated severe thermal shock; protect metal against oxidation during prolonged exposure to air at temperatures up to about 1250°F.; freedom from cracking and blistering produced in the case of porcelain enamels under comparable conditions of high temperatures and severe thermal gradients; and a mat surface that does not show highlights and, therefore, lessens visibility.

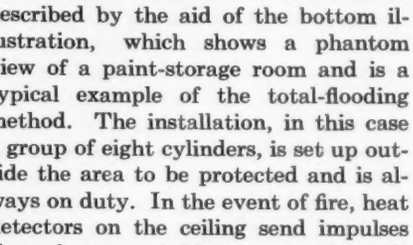
At the outset, it was the purpose of the Bureau to produce coatings for the protection of a specific metal against corrosion under special service conditions. As it turned out, that was only the beginning of a new field of development. Today, several universities and research organizations are engaged in projects sponsored by the U. S. Air Forces and the Navy Department and dealing primarily with coatings for high-temperature alloys. Among the articles for which ceramic coatings are being sought are turbine blades, combustion chambers, and essential parts of temperature- and pressure-measuring devices.

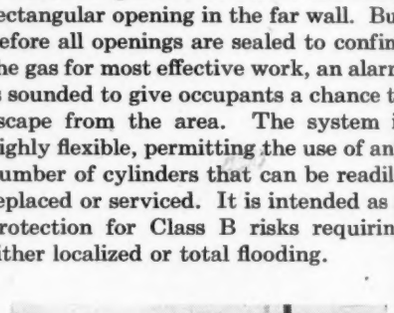
There are two fundamentally different services for which ceramic coatings are suitable. One is a long-time service (hundreds or even thousands of hours) within a temperature range that may be arbitrarily set at 1200-2000°F. The other is short-time service (a few seconds to perhaps five or ten minutes) where gas temperatures may reach 3500° and more. Within limits, and subject to further improvement, these conditions can be met at the present time. But the combination of the two—long service period and high-temperature range—is a goal still to be attained.

A detailed report, titled *Ceramic Coatings for High-Temperature Protection of Steel*, has been published by the National Bureau of Standards, Washington, D. C.

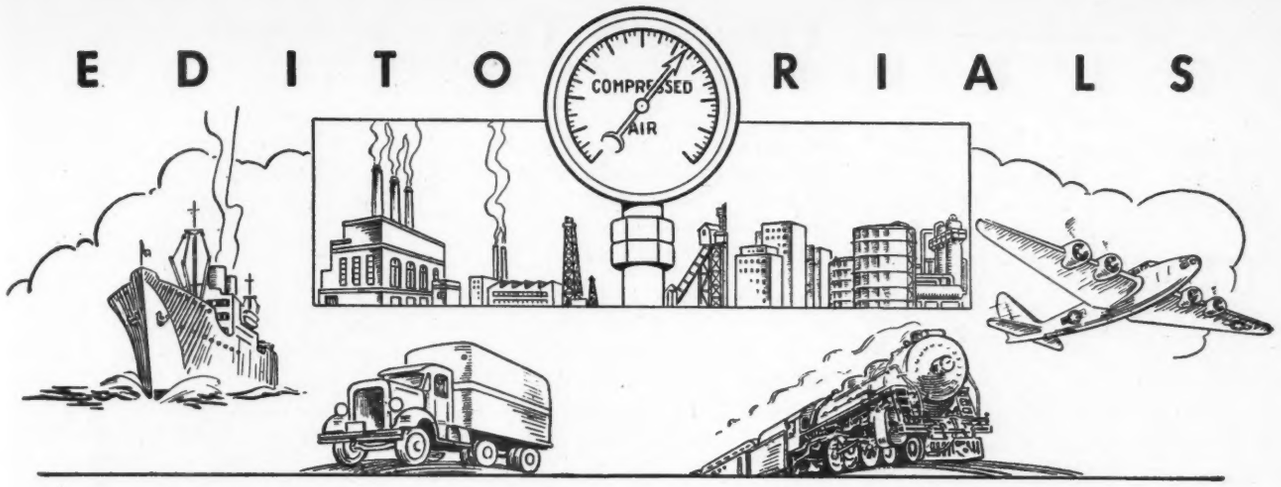
A Robot Fire-Extinguishing System

CARBON-DIOXIDE fire-extinguishing systems are not new, but a recent development along this line by American-La France-Foamite Corporation has some unusual features. It can best be described by the aid of the bottom illustration, which shows a phantom view of a paint-storage room and is a typical example of the total-flooding method. The installation, in this case a group of eight cylinders, is set up outside the area to be protected and is always on duty. In the event of fire, heat detectors on the ceiling send impulses through copper tubing to an automatic release at the cylinder battery. This release operates the valve on each cylinder through the medium of a pilot seal, thus liberating the fire-killing gas into the piping system that extends to every part of the room. At the moment of discharge, the pressure of the gas serves to trip special latches that normally hold doors and windows open. At the same time, the motor of a ventilating fan is shut down by an electric switch, a guillotine shutter drops over the air inlet, and a screen of gas shoots across the small rectangular opening in the far wall. But before all openings are sealed to confine the gas for most effective work, an alarm is sounded to give occupants a chance to escape from the area. The system is highly flexible, permitting the use of any number of cylinders that can be readily replaced or serviced. It is intended as a protection for Class B risks requiring either localized or total flooding.





EDITORIALS



SAFETY IN INDUSTRY

ACCORDING to a report from the National Safety Council, the accident record in American industry is improving. Last year the 40 divisions that submitted the returns used in compiling the records operated with a factor of safety 10 percent greater than in 1946. The average number of disabling injuries per million man-hours worked was 13.26. The communications industry registered the lowest accident-frequency rate of 2.98, and manufacturers of electrical equipment were second with 6.02. The accident severity rate also was reduced by 7 percent, the 1947 over-all figure being 1.23 days lost per 1000 man-hours. Here, again, communications ranked best with a rate of 0.16.

As is to be expected, mining, quarrying, and heavy construction are among the most hazardous undertakings. All are showing steady improvement, however, and are relatively safe, as compared with a quarter of a century ago. One reason their record is not better is the difficulty of maintaining close supervision over the workers. Most of them are more or less on their own responsibility a good part of the time. Management can and does preach the gospel of safety long and often. It employs safety engineers, holds regular safety meetings, and erects safeguards against all foreseeable accidents. It cannot, however, prevent men from occasionally acting thoughtlessly or too quickly.

That these industries are not inherently dangerous is proved by the fact that thousands of workers have spent years in them without a mishap. The trend towards mechanization is helpful, for it removes many opportunities for men to exercise bad judgment. At the same time it makes the record seem worse because the accidents that do occur are distributed among fewer workers than was the case when veritable hordes were required to excavate and move dirt and rock.

It is noticeable that wherever people can be schooled to do a thing a certain way there are fewer accidents. In factories, for instance, experience has pointed out most of the common hazards, and controls for machines or employees can be instituted to counteract them. But no amount of protection or cautioning will prevent some individuals from taking chances. The man who has been taught to be careful on his job is frequently a flagrant offender of safety laws when he leaves his work.

Industry's safety record is excellent compared with that of our highways and city streets where drivers and pedestrians alike ignore signs and the dictates of their better judgment to save a few seconds. For that matter, the bathtub is still our most prolific cause of accidents. Yet thousands of men take baths in industrial plants before going off shift and rarely sustain injury. The reason is that industry, giving thought to making the facilities safe, installs showers with nonskid floors and provides all other possible safeguards against danger. The average American, however, still doesn't seem to mind risking his neck, or at least his back, when in his own home.

THE 1948 ROAD SHOW

AS EARLY as the year 427 trade fairs were held in Europe, and they were common in the Low Countries by the tenth century. One at Champagne, France, became international in scope, although the word "international" had a narrower meaning in those days than now. Following the Norman Conquest, trade between England and the Continent increased, and fairs multiplied in the British Isles. Most famous of the European goods exhibits was the one at Leipzig, Germany, which was inaugurated in 1170. It has been held regularly through the centuries except for interruptions occasioned by wars, and has been resumed since the cessation of the last conflict. When reestablished in 1922, following suspension during World War I, it drew 155,000 buyers of whom 32,000 were from countries other than Germany.

Originally, trade fairs grew in importance serving as central market places. Transportation was difficult and time-consuming and it was more convenient for prospective buyers to visit one city rather than several. Different communities specialized in the making of one or more products, and customers interested in what they had to offer went there. Thus one city became famous for its lace, another for pottery, and so on.

Modern American counterparts of these fairs are the "shows" that are held in connection with conventions of societies and associations allied with various industrial fields. Thus we have the Power Show, the Chemical Show, and a long list of others. The exhibits consist of the latest types of equipment available for the particular industry involved. Each participating manufacturer has on hand informed salesmen and factory representatives who are intimately acquainted with the products or machinery shown. Many of them supplement their displays with motion pictures or other visual aids to explain the construction or operation of their apparatus or equipment. Not a few have models or full-size units that are actually working. Visitors may see and learn as much there in a few days as they could in weeks of travel to the widely scattered factories whence the exhibits came.

Ranking first in point of size and well up in the list as regards importance to the average citizen is the Road Show, an adjunct of the convention of the American Road Builders' Association. When first held at Columbus, Ohio, in 1909, it was termed a "hazardous experiment." Nevertheless, 40 manufacturers participated, and their 40,000 square feet of exhibits were viewed with great interest by the 1000 delegates in attendance. This month the Road Show is being revived after an 8-year wartime lapse. Too big for any indoor auditorium, it will be staged in Soldier Field, Chicago, Ill., with more than 300 exhibitors utilizing 32 acres of display space. Among the 100,000 out-of-town visitors expected will be 1000 highway engineers from foreign nations.

This and That

Oil-Shale Research Progresses

With our petroleum industry straining to meet the growing demand for its products, technologists are pursuing every possible line of investigation to safeguard our future oil supply. Since the war ended, the U.S. Bureau of Mines has been busy at its Rifle, Colo., experimental plant seeking the most effective method for extracting oil from shale. A considerable quantity of the recovered fluid was recently sent to eastern laboratories in order that they might work on suitable refining processes. Meanwhile, it seems that the private oil companies which own most of the billions of tons of western shales have not been idle. Last month the head of the Union Oil Company of California announced that it has been running a pilot plant on the Pacific Coast and is now building a larger one in Colorado. One result of the work thus far is the development of a method of burning the carbon remaining in the shale residue to provide heat for the extraction process. This promises not only to make the operation self-supporting but also to reduce the use of water, which is very scarce in the areas where the shale deposits are located.

★ ★ ★

Gold-Camp Railroad May Quit

The plight of the once celebrated gold camp of Cripple Creek, Colo., is epitomized by an application filed by the Midland Terminal Railroad with the Interstate Commerce Commission requesting permission to cease service. The line runs from Cripple Creek to Colorado Springs and virtually all its recent business has consisted in transporting ore to the latter city for treatment in the Golden Cycle Corporation's mill. It suspended passenger service in 1943. The railroad is the last of three that once connected lofty Cripple Creek with the plains section 5000 feet below. Originally, under the name of Colorado Midland Railway, it extended beyond the gold camp, its 221 miles of costly track crossing the Continental Divide. Years ago all the rails were torn up except the 56-mile stretch that now remains. Since the gold mines were shut down by government order in 1942, Cripple Creek has been unable to stage much of a comeback, and the mines are operating at only partial capacity. The mill at Colorado Springs which, incidentally, is the largest custom plant of its kind in the country, has been kept going largely with low-grade dump ore that was discarded during Cripple Creek's early years. The Golden Cycle Corporation owns all the stock in the Midland Terminal Railroad and also controls most of the active mines. The application for abandonment of service states that the mill will be moved to Cripple Creek, thus eliminating the need for transportation facilities.

★ ★ ★

Steam Bows to Diesel

Further evidence that the diesel-electric locomotive is fast crowding the venerable steam-driven propulsion unit off the rails is an announcement by the American Locomotive Company that it has temporarily ceased building the old type of "iron horse." For the first time in its century of existence the concern has no orders for "steamers," the last one having been shipped from its Schenectady, N. Y., shops on June 9. On the other hand, its

"I located the leak under the bank."

112-acre factory is busy assembling diesel-electric locomotives. The company will, of course, continue to make any steam units that are wanted, but it expects few requests for them. Showing the present trend are figures obtained from the Association of American Railroads on 1947 locomotive business. Of the 1503 ordered by the nation's lines, only 38 were steam-driven.

★ ★ ★

Canada Wars on Insects

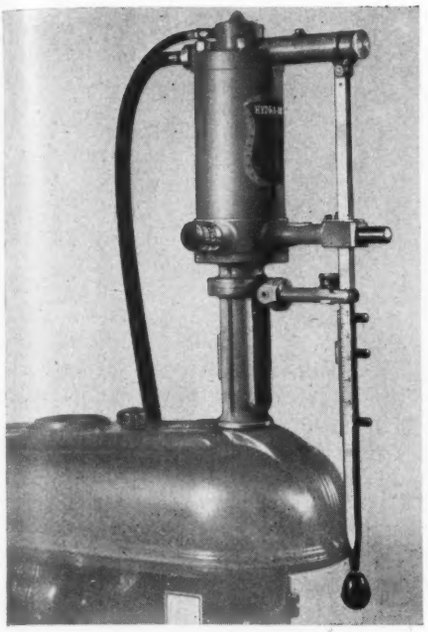
The Canadian Northland has long been in bad repute because of its biting insects. The scourge of mosquitoes, black flies, and deer flies at times makes life almost unbearable for prospectors, trappers, and fishermen who venture into the bush. Recognizing that the insect hordes are a deterrent to the development of the outposts, the Dominion Government is launching a retaliatory campaign. The first step is a survey of the life habits of the pests, which is being conducted this summer. Eight parties have taken to the field, and a laboratory has been established at Fort Churchill. Using airplanes to transport them to widely scattered areas, the men will remain until August. The personnel consists mainly of students and faculty members of various universities. Their job is to collect insects, observe their breeding and biting habits, note the effects on them of weather and vegetation, and compile 24-hour timetables of their activity. Observations around the clock are necessary because it is already known that the insects work in shifts, one species becoming active when another retires for rest. A spot check at Fort Churchill last year identified ten biting and various nonbiting types of mosquitoes, twelve species of black flies, and nine or ten kinds of deer flies. Some of the pests range from 10 to 25 miles, and the spraying of one area is ineffective because new hordes move in as soon as the original tenants have been liquidated. The field parties will try out various repellants and also a newly designed pest-proof suit. Eventually, an entomological map of the entire North Country will be prepared to indicate the intensity and severity of the insect population by sections. One phase of the study will be to note the effect of insect control on the prevalence of fish in northern lakes.

★ ★ ★

Navy Tells of Using Air Bubbles

Compressed air, bubbling up from perforated submerged pipes, maintained a quiet zone around a Pearl Harbor dock where the Navy was conducting noise-reducing experiments on submarines during the height of the war. This was revealed recently in a paper presented before the Acoustical Society of America. The curtain of bubbles rising through the water at the entrance to the dry dock kept out low- and high-frequency noises but did not interfere with submarines entering or leaving the enclosure. The tests were carried out in the interest of making it more difficult for the enemy to detect our underwater craft. The idea of the air-bubble screen was conceived by Philip Brasher more than 25 years ago as a means of calming rough seas. Since then it has been put to numerous practical uses such as preventing the formation of ice at the entrances to hydroelectric turbines.

Industrial Notes

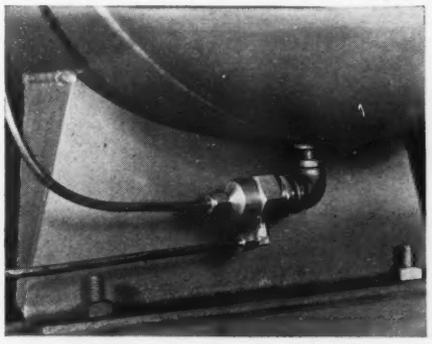


An automatic feed adaptable to most standard makes of drill presses has been announced by the General Pacific Corporation. The unit is operated with air at 85-125 pounds line pressure, and the drilling cycle involves rapid traverse to work surface, controlled feed through work, and quick return. Machine is set by means of a scale graduated in sixteenths and by a micrometer adjustment graduated in thousandths to vary depth of hole and drill holes of predetermined depth consistently. Rate of feed is hydraulically controlled, and a graduated dial permits a widely variable feed throughout the entire range. Designated as Hydra-Drill, the unit has sufficient power to feed a drill ⅝ inch in diameter through steel. A special skip-drilling attachment is provided to drill channels, piping, etc. There are two models which differ only in that one is equipped for use in conjunction with an automatic indexing fixture for continuous production.

Something new in roofing materials for crude-oil storage tanks in the tropics has been announced by the Industrial Mineral Wool Institute. Metal plate is commonly used for the purpose but has to be renewed in from six to eight years because of the deteriorating action of sun and rain, as well as fumes within the tanks. With fifty 55,000-barrel units to be reroofed, a Gulf Coast company looked about for something that would last longer and has found it, it is claimed, in a compound with a mineral-wool cement base. Reinforced with 12-gauge wire mesh, the material is poured in place to a thickness of 2 inches. According to the announcement, a roof of this kind is no heavier than one of ¾-inch steel plate, is proof against moisture and lightning, withstands excessive expansion and contraction, maintains more uniform temperatures inside the tank, and reduces to a minimum losses through evaporation and breathing of the more volatile fractions of the stored petroleum.

Demand by nonferrous foundries for a tough and hard cutoff wheel that would cut fast with safety and last long has resulted in the production by the research staff of Norton Company of what is known as the Norflex wheel. It is a reinforced resinoid wheel whose normal cutting action, imparted by multiple sharp points and edges of grains of abrasive Alundum in its periphery, is increased by concentric rows of molded "teeth" which give its sides filelike surfaces. At present it is available in three standard diameters—14, 16, and 20 inches; in two thicknesses—$\frac{5}{32}$ and $\frac{3}{16}$ inch; and in three grades—soft, medium, and hard.

Manual draining of water and oil accumulating in air tanks is eliminated, it is claimed, by the Lansdale Water Unloader which is distributed by A. Shelburne Company, manufacturer of paint-spray guns and equipment. It is designed to fit any electrically operated compressor equipped with a centrifugal or magnetic unloader, and automatically draws off the harmful oil-bearing water as it collects in the receiver. The danger of forcing it into air lines is thus minimized, and corrosion and clogging of tools are prevented. The unloader itself is protected from damage by rust and dirt by inserting a filter or screen of wire mesh ahead of the mechanism.



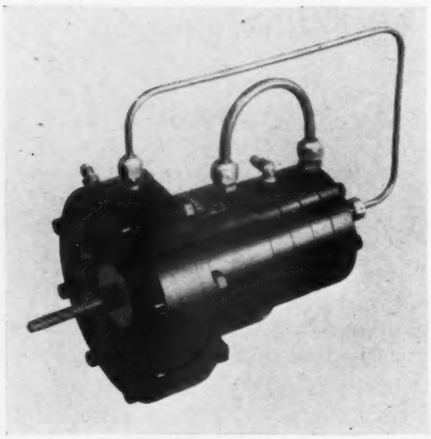
As a protection for metal piping, fittings, etc., exposed to corrosive fumes and acids, for sealing rubber tubing, and for making all manner of temporary repairs, Minnesota Mining & Manufacturing Company is offering a plastic-film Scotch tape in yellow, black, or white. It is said to have high resistance to acids, alkalies, alcohol, aliphatic hydrocarbons,

SAVES MATERIALS HANDLING

Manufactured and used by the Monroe Auto Equipment Company, the drop-bottom skid box shown has cut out considerable lost motion in delivering dust shields to an assembly line for incorporation in shock absorbers. Formerly, the work pieces were put into ordinary tote boxes after stamping and coding, moved by lift truck, and transferred from there by hand to the conveyor. Now the machine stands alongside the latter, and the dust shields are fed to the operator by gravity from the improved-type skid box. After stamping, he places them on the chute at the left that feeds the assembly line.

oils, and salt water; to withstand aromatic hydrocarbons to a lesser degree; and to be soluble in ketones and certain esters. It is made in rolls of 36 yards and from ¼ inch to 22 inches wide.

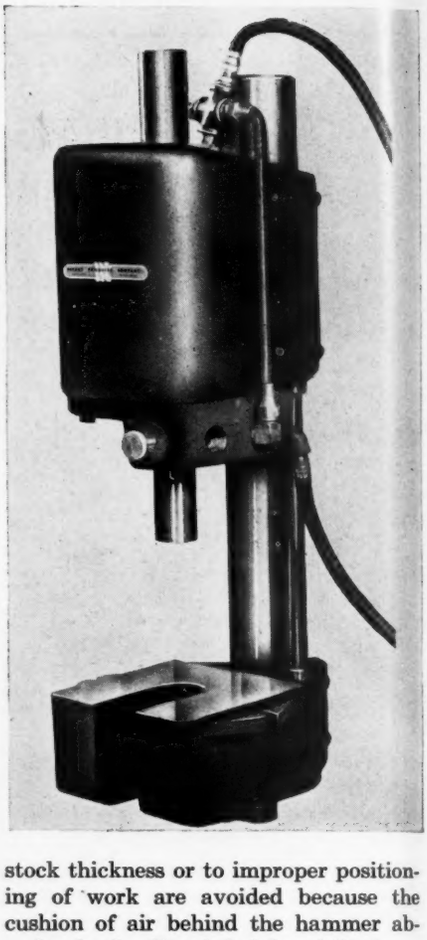
For oil-burner tips, injection nozzles, governor gear on boiler feed pumps, and other equipment that require precise positioning over a short distance, Hagan Corporation has introduced a pneu-



matic Micropositioner that also exerts considerable power. Using air at 60 psi. pressure it can, for example, position a lever within a few thousandths of an inch over a range of 0 to 0.5 inch, working without mechanical linkage.

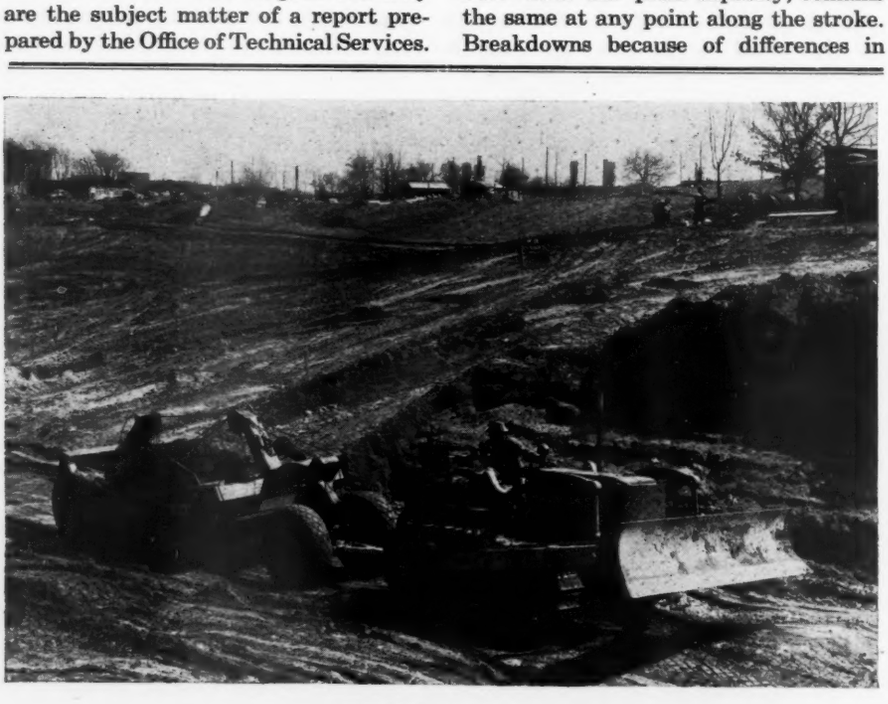
Investigations and practical experience with zinc-base bearings in Germany are the subject matter of a report prepared by the Office of Technical Services. It is described as a new and not a substitute bearing material suitable for use in machine tools, electric motors, driving rods, coupling rods and axles of locomotives, for transmissions of cranes, crushers, and other machinery, etc. To quote the report, "Compared with red brass, tin bronze, white metal with a high-tin content, and lead-base bearing alloys with a low-tin content, the zinc alloys are superior in tensile and fatigue strength and in hardness. They are far superior to the standard bearing materials in respect to thermal conductivity, and can be used as solid bearings because of their high tensile strength at low temperatures." Mimeographed copies of the 16-page report (PB-42654) can be obtained for fifty cents from the Office of Technical Services, Department of Commerce, Washington 25, D. C.

Using compressed air at 100 pounds line pressure, the newest addition to the Bryant line of air-hydraulic presses is said to deliver impacts ranging from 1 ounce to 12,000 pounds. According to the manufacturer—Bryant Products Distribution Company—the blows obtainable are remarkable in a press of its size and are effected by what he terms "exploded air"—by equalizing the air at both ends of the piston and then suddenly exhausting it below the piston. Stroke is constant—is not set to fit the job as in mechanical presses—and the impact pressure, which may be varied in accordance with the press capacity, remains the same at any point along the stroke. Breakdowns because of differences in



stock thickness or to improper positioning of work are avoided because the cushion of air behind the hammer absorbs shock. Bench height of the hammer is 27 inches, piston stroke 3 inches, and power unit can be adjusted on the post. Speed of operation by hand or foot control is about 60 strokes a minute. By adding a solenoid valve and guide-rod switches, press can be made fully automatic. The Air Impact Hammer, as it is designated, is designed for light stamping and forging, trimming, molding, crimping, coining, riveting, piercing, and forming metals.

Not long ago, an advertisement appeared in trade papers announcing that the Burke Electric Company of Erie, Pa., was looking for the oldest Burke motor or generator still in use. Many "aged" units still going strong were located, but the search ended when the very first motor-generator set to bear the Burke nameplate was discovered in active service at the Crystal City plant of the Pittsburgh Plate Glass Company. It is now in its 41st year of operation. Speaking of the unit, F.E. Mahew, chief electrician, says: "One of my first jobs at Crystal City when I was employed on September 22, 1909, was the inspection of the Burke Motor Generator Set purchased in 1907 and installed on a narrow-gauge railway to furnish current for several locomotives. I must say that this generator could, and did, take some high current punches. In 1926 we rewound the A. C. end and shipped the unit to our Ford City Plant for use in the ma-



EARTH MOVER

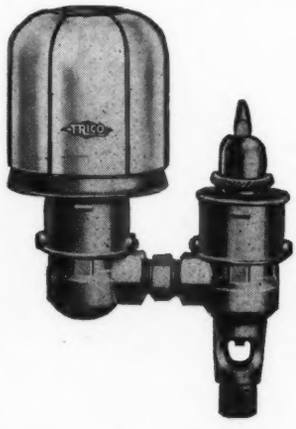
This unit is one of a new line of Bucyrus-Erie cable-controlled, 4-wheel, S-Type scrapers ranging in capacity from 4 cubic yards for the S-46 to 10 for the S-113. They feature a low center of gravity, widespread rear wheels, and low bowl height which, combined, provide stability for side-sloping; a hinged apron with an adjustable opening for clean discharge of sticky material; and positive return of bowl to loading position on any slope. The machines are said to possess more than ordinary maneuverability. The scraper shown is the 6-cubic-yard S-68 working with a bullgrader mounted on an International crawler tractor.

chine shop. In 1941 it was changed back to 2300 volts, 3-phase, 60-cycle and relocated at our sand mines. It continues to supply current for two shovels with 1¼-cubic-yard dippers and a 10-ton and 15-ton electric locomotive. In 1947 we mined 180,000 tons of sand." Mr. Mahew was awarded an engraved watch by the Burke Electric Company, which maintains that no matter how carefully a product is built much credit is due its caretaker if it gives exceptional continuous service.

Automotive Air Compressor Manufacturers has initiated a program of labeling compressor units to indicate whether they comply with commercial standards. A plate is to be attached with such data as minimum over-all efficiency and maximum motor and ASME tank load.

Tank Kleen, Formula No. 101, is a new product announced by Celco Corporation and is described as a cleaner that prevents the formation of binders such as gums and tars in oil, gasoline, kerosene, and other fuel-oil systems of burners, engines, or power units of any type or size. Added directly to the fuel, the fluid is said to convert all soluble hydrocarbon binders into a liquid that burns with the fuel.

For solid bearings where precise feed and clean, filtered lubricant are essential, Trico Fuse Mfg. Company recommends its new gravity oiler. The unit is mounted on top of the part to be lubricated and can be set by a needle valve to deliver any predetermined number of drops. With the adjustment made, the only attention required is to keep the reservoir filled. The latter is made of clear, shatterproof plastic and is removable.



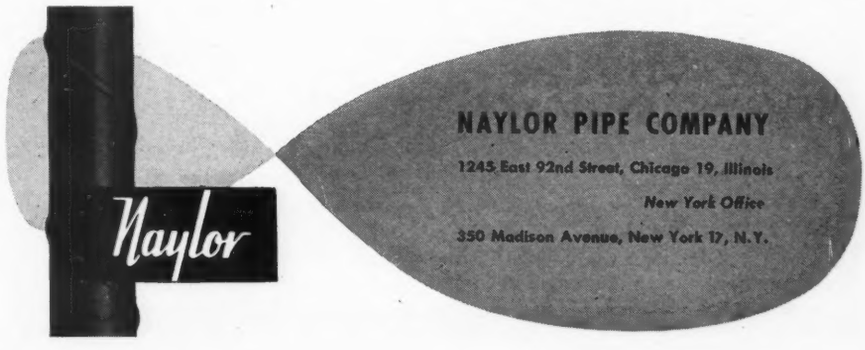
Patented filter, also removable, prevents dust and dirt from reaching the bearing and clogging the needle valve. The operating lever can be set in three positions: vertical, to feed oil; tilted, to stop the flow; and at a 45° angle to flush the bearing before starting a machine. The oiler comes in four sizes ranging in capacity from 1 to 8 ounces.

It's NAYLOR *Light-weight* PIPE

Here's the one light-weight pipe built to handle both high and low pressure jobs in mining service. The exclusive Lockseam Spiralweld creates a reinforcing truss that increases collapse strength and thus makes Naylor stronger and safer than ordinary light-weight pipe. That's why mine operators prefer Naylor for permanent as well as temporary lines. Sizes from 4 to 30 inches in diameter.

Coupled with NAYLOR *Wedge-Lock Couplings*

Another NAYLOR contribution is the Wedge-Lock Coupling—the last word in speed, simplicity and economy of pipe connection. Built in one piece with gasket in place, it can be quickly and easily connected or disconnected by means of a hammer. Two types—for high or low pressure service.



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New Books

To commemorate its fiftieth anniversary, the Canadian Institute of Mining and Metallurgy has published a symposium volume entitled *Structural Geology of Canadian Ore Deposits*. Recognizing the fact that geologic features control the emplacement, form, and extent of ore deposits, the book contains the known facts concerning the structural relationships of the Dominion's ore deposits. In its 132 separate papers, written by 127 of Canada's leading geologists and mining engineers, are described the structural features of nearly all the country's metal mines and mining camps. Illustrations included in the 950-page volume consist of more than 340 line drawings and numerous black-and-white and full-color photographs.

The volume may be obtained from the Institute, 906 Drummond Building, Montreal, Que., Canada. Price $10. Qualified students may obtain a copy at a 20 percent discount.

The fourth edition of *Steam, Air and Gas Power*, by William H. Severns and Howard E. Degler, has recently been published. Designed as an elementary text book for students of power and heat engineering, it combines theory with practical applications of typical, modern equipment used in this field. Discussions and illustrations explain the theory underlying the construction, application, and performance of heat-power plants and their correlated equipment.

Material contained in the previous editions has been revised to include present-day developments, one of the most important of which is the gas turbine. The subject matter has also been rearranged for easier reading. Problems, most of which are new in this edition, have been included at the end of each chapter to give the reader practice in applying the principles as he learns them.

Steam, Air and Gas Power is published by John Wiley & Sons, Inc., New York, N. Y., price $4.75.

Industrial Literature

Equipment for the sugar industry is listed in Form 140 obtainable from Ingersoll-Rand Company. Air tools, compressors, diesel engines, pumps, and vacuum equipment are described and illustrated in the 16-page bulletin, copies of which may be obtained by writing to the company at 11 Broadway, New York 4, N. Y.

Sheet-metal fabricators may be interested in obtaining Bulletin No. 1001 from Progressive Welder Company, 3050 East Outer Drive, Detroit 12, Mich. The bulletin describes a number of different products that are being fabricated quickly and at low cost in contract sheet-metal shops with standard resistance-welding equipment.

Details of the Wilder Micro Projector are given in a folder obtainable from the George Scherr Company, 200 Lafayette Street, New York, N. Y. The instrument casts greatly enlarged projections of small parts onto a ground-glass screen so that inspection and checking of dimensions can be done quickly and easily. The projector is available in both horizontal and vertical models.

Brooks Rotameter Company Lansdale, Pa., has issued a catalogue describing its line of instruments for the measurement and control of flow rates in liquids and gases. Instruments for remote recording, automatic control, or totalization of flow rates are

available for both normal and high pressures and temperatures. Capacity charts, data sheets, and dimensioned prints are given for each type of meter.

Bulletin No. 352 of Imperial Brass Manufacturing Company is intended as an aid in identifying various types of fittings for brass tubing. Cross-sectional views of fitted joints, as well as of the same joints disassembled, are given for the different types of fittings commonly used. Copies of the folder may be obtained by writing to the company at 1200 West Harrison Street, Chicago 7, Ill.

Strainers for use in water mains are described in Catalogue No. 37 of R-S Products Corporation, Philadelphia, Pa. Designed for continuous operation, each unit incorporates within its main casing two basket strainers so arranged that one will continue to function while the other is being cleaned. Engineering drawings, dimensions, and graphs of pressure loss and flow rates are given for the six standard-size strainers that are built for pipes 4 to 24 inches in diameter.

Data on the use of "O" sealing rings on hydraulic and pneumatic machinery are contained in an 8-page manual obtainable from Crane Packing Company, 1800 Cuyler Avenue, Chicago 13, Ill. Dimensional standards and recommendations as to the kind of sealing compound to be applied are given for "O" rings used either as a gasket- or moving-type seal. Information is also included on prolonging the life of the rings by preventing wear.

Selection and fabrication of solid stainless-steel and stainless-steel-clad plates is dealt with in a 32-page book issued by Allegheny Ludlum Steel Corporation. The data includes charts and tables giving available sizes, thicknesses, and weights of the material, as well as sections on analysis selection, shop work, cutting, machining, forming, welding, and annealing. Copies of the booklet will be sent upon written request to the company at Pittsburgh 22, Pa.

A new model diesel engine designed for such tasks as oil-well drilling, logging, irrigation, and electric-power generation is described in literature obtainable from Waukesha Motor Company, Waukesha, Wis. A unique feature of the engine is the cooling of the piston crowns by intermittent circulation of oil under pressure from the lubrication system. The engine is a 6-cylinder model that develops 300 hp. at 900 rpm.

Electric Machinery Manufacturing Company, Minneapolis 13, Minn., will send upon request information and a wall chart giving details of the firm's latest model drip-proof, 2-pole, squirrel-cage induction motor. The unit ranges in size from 200 to 700 hp., operates at 3600 rpm., and can be used for driving centrifugal pumps, compressors, blowers, and similar machinery. Also available is Volume 8, Number 2 of the *E-M Synchronizer* which describes the construction and lists the advantages of drip-proof motors.

Flexible brass tubing manufactured for automotive, aircraft, and other industrial uses by Titeflex, Inc., is described in a 24-page catalogue recently published by that company. Other products listed are bronze tubing for nominal steam-pressure applications; monel and stainless-steel tubing for higher temperatures and resistance to corrosion; inconel tubing for extremely high temperatures; and bendable pipe, high-frequency conductors, and vibration eliminators. Copies of the catalogue will be sent upon request to the company at 480 Frelinghuysen Avenue, Newark 5, N. J.

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